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► **To cite this version:**

Lionel Fontagné, Houssein Guimbard, Gianluca Orefice. Product-level Trade Elasticities. 2019. hal-02444897

HAL Id: hal-02444897

<https://hal.science/hal-02444897>

Preprint submitted on 24 Jan 2020

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Highlights

- Trade elasticity is a crucial parameter in evaluating the welfare impacts of trade liberalization.
- We estimate trade elasticities at the product level (6-digit of the Harmonized System) by exploiting the variation in bilateral applied tariffs for each product category. The obtained trade elasticities are centered around -5.
- We show that using homogeneous - instead of heterogeneous - trade elasticity across products implies a downward bias in welfare gains from trade in particular for poor and developing countries.



Abstract

Trade elasticity is a crucial parameter in evaluating the welfare impacts of trade liberalization. We estimate trade elasticities at the product level (6-digit of the Harmonized System comprising more than 5,000 product categories) by exploiting the variation in bilateral applied tariffs for each product category for the universe of available country pairs. This is done by constructing a panel of bilateral applied tariffs and bilateral trade covering the period 2001 to 2016. We address potential endogeneity issues as well as heteroskedasticity and selection bias due to zero flows. The obtained trade elasticities are centered around -5. We finally highlight the differences in the gains from trade arising from considering heterogeneous rather than average trade elasticities. All product level elasticities are made publicly available for sake of scrutiny and use by other researchers.

Keywords

Trade Elasticity, International Trade, Tariffs, Welfare Gain.

JEL

F14, F17.

Working Paper

CEPII

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CEPII Working Paper
Contributing to research in international economics

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Editorial Director:
Sébastien Jean

Production:
Laure Boivin

No ISSN: 1293-2574

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Product-Level Trade Elasticities¹

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1. Introduction

Trade elasticity is an important parameter in international trade models, especially when it comes to provide an order of magnitude of the welfare impacts of trade liberalization, or conversely the cost of returning to autarky: the welfare gain from trade is a function of the change in the share of domestic expenditure and the trade elasticity to variable trade costs (Arkolakis, Costinot & Rodriguez-Clare 2012). If one assumes that a tariff is mostly a variable trade cost imposed by the importer country, then the elasticity of trade values to changes in tariffs becomes the key parameter for many scholars and practitioners aiming at evaluating the welfare effect of changes in trade policy – see the approach coined as trade theory “with numbers” popularized by Costinot & Rodriguez-Clare (2014).² A relatively closed economy (typically a large country), or a country in which imports have close domestic substitutes, will suffer little pain from moving to autarky as trade-induced welfare losses are small (Costinot & Rodriguez-Clare 2018). But while the first statistic – how much does a country trade with itself as a proportion of its total expenditures – is directly observable, available estimates of

¹We are grateful to Antoine Bouët, Carsten Eckel, Lisandra Flach, Christophe Gouel, Yoto Yotov, Mario Larch, Thierry Mayer, Andres Rodriguez-Clare and John Romalis for helpful comments. We also thank participants to CEPII (Paris), LMU (Munich) seminars, GTAP and ETSG 2019 conferences.

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²We consider in what follows that the current tariffs are applied at the date of the trade flow. They may differ from future tariffs to the extent that tariffs are consolidated above the applied or even not consolidated. Tariffs of advanced countries are fully consolidated however.

the trade elasticity diverge considerably.³ In their survey of open questions related to the analysis of commercial policies, Goldberg & Pavcnik (2016) stress that "*perhaps surprisingly, estimates of the trade elasticity based on actual trade policy changes are scarce [...] it is surprising that trade policy has not been exploited to a larger extent to identify this crucial parameter*".⁴ This paper aims at filling at least partially this gap. By systematically scanning applied protection and import flows at the bilateral and product level for a full matrix of bilateral trade, we provide a set of estimations of theory-consistent trade elasticities at product level. So doing we will have a comprehensive view of trade policies, including for countries having hardly liberalized their trade, and that are generally absent from existing studies.⁵ Also, this paper illustrates the bias introduced by using homogeneous (average) rather than product-specific trade elasticities in the evaluation of welfare gains from trade.

Trade elasticity can be estimated at different levels of disaggregation ranging from the sector to the product or even the variety. In the latter case, it has to be estimated at the level of individual exporters using transaction-level custom data,⁶ with the challenge that export prices and export quantities are endogenous at the firm level.⁷ To overcome this difficulty, and also because firm level exports are hardly available for multiple countries,⁸ we rely here on the finest grain – the HS 6-digit product level – when firm-level data is not available. By doing so, we implicitly aggregate firms (at different levels of productivity) within a given exporting country-product cell; in this case the shape of the distribution of productivity within the cell will indeed impact the observed elasticity (Chaney 2008).⁹ Sector level trade elasticities are

³For example, the trade elasticities estimated by Eaton & Kortum (2002) range from 3.6 and 12.8; while Caliendo & Parro (2015) find trade elasticities ranging from 0.49 in the "Auto" sector to 69 in the "Petroleum" sector.

⁴See Goldberg & Pavcnik (2016) pp. 24-25. Two exceptions are Amiti, Redding & Weinstein (2019) and Fajgelbaum, Goldberg, Kennedy & Khandelwal (2020) who take advantage of the big swings in US tariffs and rely on US imports from January 2017 to December 2018 at the origin-month-HS10 level. Amiti et al. (2019) estimate an elasticity of substitution between varieties equal to 6 (see column 3 of table 1 accounting for zero flows.) Fajgelbaum et al. (2020) preferred value for US import demand elasticity is 2.47.

⁵Simonovska & Waugh (2014a) stress that trade elasticity estimates relying on advanced countries' only, due to data limitation, may not be accurate to evaluate welfare changes for developing countries.

⁶A variety is then defined as a specific product produced by a specific firm.

⁷Fontagné, Martin & Orefice (2018) use a firm level time varying instrumental variable for export prices and estimate firm-level elasticity to tariff controlling for how exporters absorb tariff shock in their export price.

⁸Bas, Mayer & Thoenig (2017) is an exception, as they managed to combine French and Chinese firm level exports to estimate trade elasticities.

⁹Starting from firm level export data for the universe of French manufacturing firms, Fontagné & Orefice (2018) conduct estimations of trade elasticities at the sector level and show that the effect of stringent Non-

(downward) biased if the elasticity varies a lot across products and/or due to the covariance between the dispersion of tariffs across countries and the sectoral trade elasticities (Imbs & Mejean 2015). This bias is reduced here as we rely on a very disaggregated product classification.

Trade elasticity can have different interpretations based on the underlying theoretical framework and on the level of aggregation. Feenstra, Luck, Obstfeld & Russ (2014) make a distinction between the “macro” Armington elasticity between domestic and imported goods, and the “micro” elasticity of substitution between different import suppliers.¹⁰ Indeed, the two elasticities are usually nested in a (e.g. CES) preference structure.¹¹ In line with this distinction we compute here “micro” trade elasticities as we test how bilateral tariffs affect bilateral import flows.

Trade elasticity can be estimated with a demand system (Feenstra 1994, Broda & Weinstein 2006, Ossa 2015, Soderbery 2018), using the non-arbitrage condition and product-level price data (Simonovska & Waugh 2014a, Giri, Yi & Yilmazkuday 2018), considering imports as inputs in the GDP function (Kee, Nicita & Olarreaga 2008b), or based on a gravity framework (Caliendo & Parro 2015). While Caliendo & Parro (2015) rely on the multiplicative properties of the gravity equation in order to cancel out unobserved trade costs, in line with the “ratio approach” introduced by Head & Ries (2001) or Head & Mayer (2002) and systematized as “Tetrads” by Martin, Mayer & Thoenig (2008) and Head, Mayer & Ries (2010),¹² we rely here on a gravity framework using a strategy of fixed effects as suggested by Head & Mayer (2014).

The choice of an identification strategy consequently differs in terms of observed trade

Tariff Measures in reducing export flows is magnified in more homogeneous sectors, as predicted by theory.

¹⁰In a seminal paper, Armington (1969) introduced a preference model whereby goods were differentiated by their origin – domestic *versus* imported.

¹¹See e.g. Hertel, Hummels, Ivanic & Keeney (2007) who obtain elasticities of substitution between goods of different origins, at the sector level, ranging from 1.8 to 12.9 (excluding gas, the usual outlier).

¹²The triple differentiation approach proposed by (Caliendo & Parro 2015), however, differs from the odds ratio and the “tetrad” approach as it does not require domestic sales data (combination of gross production and trade flows), and it does not need a reference country to identify parameters. The triple difference approach relies on the assumption that tariffs are the only non-symmetric trade costs (all other trade costs are assumed symmetric and therefore cancel out in the triple difference).

costs. Estimating a demand system will resort to volume and prices at the finest level of the classification of traded products (Feenstra 1994) with no *explicit* consideration of the trade policy. The latter is assumed to be fully passed into the prices at the border. Similarly, in Simonovska & Waugh (2014a) and Giri et al. (2018), the maximum price difference between countries for detailed price level data for the year 2004 is a proxy of trade frictions.¹³ Unit values are used as proxy of prices in Kee, Nicita & Olarreaga (2008a), when estimating the import demand elasticity as the percentage change in the imported quantity holding prices of other goods, productivity and endowment of the importer constant. In contrast, Caliendo & Parro (2015) rely on the cross-sectional variations in trade shares and applied tariffs for 20 sectors and 30 countries to estimate sectoral trade elasticities.

In this paper we aim at covering the largest number of importing countries and the finest degree of product disaggregation in our estimations, hence our choice of relying on actual trade policies. To proceed, we use the most disaggregated level of information on trade policies and imports available for the universe of products and importing countries,¹⁴ which is the 6-digit Harmonized System (HS6 thereafter) comprising more than 5,000 different product categories for a sample of 152 importing countries. A typical product category here will be “Trousers, bib and brace overalls, breeches and shorts; men's or boys', of textile materials (other than wool or fine animal hair, cotton or synthetic fibres), knitted or crocheted”. Since we use bilateral trade data at the product category level, we do not observe the differentiation of products among firms of a given exporting country. However, given the very disaggregated product category, this concern is very reduced here. We compute the tariff elasticity (and recover trade elasticities accordingly) comparing sales of e.g. Indian and Chinese trousers and shorts on importing markets, controlling with destination fixed effects for any systematic difference in elasticities among importers.¹⁵ For each HS6 product category we observe the

¹³Simonovska & Waugh (2014a) use disaggregated prices from the International Comparison Programme for 62 product categories matched with trade data in a cross section of 123 countries. Giri et al. (2018) adopt the same strategy for 12 EU countries and 1410 goods (in 19 traded sectors) in 1990.

¹⁴Indeed, imports can be observed at the tariff line for single countries. This is why US imports have repeatedly been used to estimate trade elasticities. An influential set of elasticities at the tariff line level for the US (13,972 product categories) and the 1990-2001 period is Broda & Weinstein (2006).

¹⁵Broda, Greenfield & Weinstein (2006) examine whether substitution elasticities vary systematically in relation with the income per capita of the importer and find no such evidence notwithstanding idiosyncratic differences across countries. In contrast they obtain large differences in elasticities among goods: the mean elasticity of

universe of bilateral trade flows between countries, in value, in a given year, and the tariff (preferential or not) applied to each exporter by each importer for this product. This information is available for the years 2001, 2004, 2007, 2010, 2013 and 2016.¹⁶ Most of the variation in tariffs is cross-sectional, we therefore exploit the panel nature of this dataset, and explain - for a given importer - the cross-country variation in imports with the cross-country variation in tariff.¹⁷

We show that, when estimated at the HS6 product-category level for the universe of products and country-pairs, the distribution of trade elasticity is centered around -5.¹⁸ However, there is large variation around this value, and our results will be useful for a wide set of exercises exploiting the product level dimension of this elasticity.¹⁹ This result compares with average elasticities presented in the trade literature: Romalis (2007) obtains elasticities of substitution between 6.2 and 10.9 at the HS6 level, while Broda & Weinstein (2006) obtain for US imports an average value of 6.6 with 2,715 SITC 5-digit categories, and 12.6 at the tariff line (13,972 categories) level for the period 1990-2001.²⁰ Using HS6 import data and unit values for 117 importers over the period 1988-2001 Kee et al. (2008a) obtain a simple average import demand elasticity of 3.12. Using a simulated method of moments and international differences in individual price data Simonovska & Waugh (2014a) present a benchmark trade elasticity of 4.12 and Giri et al. (2018) a median trade elasticity of 4.38 (minimum 2.97, maximum 8.94). At the industry level, Ossa (2014) estimates CES elasticities of substitution by pooling the main world importers in cross section and obtains a mean value of 3.42 (ranging from 1.91 for Other animal products to 10.07 for Wheat). By

substitution is much higher for commodities than for reference priced or differentiated products, using Rauch's classification.

¹⁶As discussed in Anderson & Yotov (2016), panel estimations with non-consecutive years are preferred to estimations using panel data pooled over consecutive years. The use of non-consecutive years allows for the adjustment of the dependent variable in presence of trade policy change (i.e. tariff change in our case).

¹⁷In section 2.3 we show that cross-country variation (*between* component) in import tariff is larger than the over-time variation (*within* component).

¹⁸The trade elasticity ε is equal to one minus the elasticity of substitution σ , which using FOB trade flows (as in this manuscript) equals to the negative of tariff elasticity. See section 2.4 for further discussion on this point.

¹⁹The estimated tariff elasticities are made publicly available at http://www.cepii.fr/CEPII/en/bdd_modele/presentation.asp?id=35. Estimated trade elasticity and related additional material are also available in a dedicated web page: <https://sites.google.com/view/product-level-trade-elasticity/accueil>

²⁰Notice that the median is much lower, respectively 2.7 and 3.1.

combining GTAP 7 and NBER-UN data for 251 SITC-Rev3 3-digit industries, Ossa (2015) obtains an average elasticity of 3.63 (ranging from 1.54 to 25.05). After controlling for exporter and importer fixed effects in their triple difference approach, Caliendo & Parro (2015) find trade elasticities ranging from 0.49 in the "Auto" sector to 69 in "Petroleum" sector.²¹ Other calibration exercises however point to larger elasticities: Hillberry, Anderson, Balistreri & Fox (2005) show that reproducing variations in bilateral trade shares with a standard computable general equilibrium model imposes elasticities of substitution larger than 15 in half of the sectors.²² Even restricting the comparison to the estimates relying on gravity leads to a wide range of values, as shown by Head & Mayer (2014) in their recollection of 744 elasticities present in 32 papers. In their full sample the median trade elasticity is 3.19, with a large standard deviation (8.93). Restricting the comparison to gravity estimates controlling for multilateral resistance terms and exploiting the variation in tariffs or freight rates (435 elasticities), Head & Mayer (2014) obtain a median of 5.03 which is their preferred value (still the standard deviation is 9.3). Indeed, significant differences are observed beyond these averages and we will compare our elasticities with the ones frequently used to calibrate models in the literature.

Gains from trade with heterogeneous trade elasticity across HS6 product categories raise specific issues that we explore in the second part of the paper. Namely, we compare welfare gains from trade using *heterogeneous* vs *average* (homogeneous) trade elasticities, and show that using homogeneous - instead of heterogeneous - trade elasticity across sectors implies a downward bias in welfare gains from trade in particular for poor and developing countries. This is of crucial interest for both scholars and policy makers aiming at evaluating the welfare impact of trade policies, and represents the second contribution of our paper.²³

The rest of the paper is structured as follows. We present data and our empirical strategy in

²¹See table A2 in Caliendo & Parro (2015).

²²More precisely, in a calibration-as-estimation procedure applied to the GTAP model, this elasticity had to be set at a value above 15 in 21 out of 41 sectors in order to reproduce the actual variation in trade shares. Authors failed to report solution in five sectors.

²³A related question – the heterogeneity in tariff elasticity across countries and levels of trade costs – has been recently explored by Brooks & Pujolas (forthcoming). Authors show that trade is more inelastic when the country approaches to autarky. In this case, marginal increases in the import penetration for countries close to autarky imply larger welfare effects than for countries close to the observed trade.

Section 1. Our trade elasticities estimated at the product level are given in section 2. In section 3 we compare the elasticity estimated in this paper with those obtained by other papers. In section 4 we perform a standard calculation following Arkolakis et al. (2012) and compare the change in welfare from moving to autarky obtained using heterogeneous elasticity *versus* adopting an average (product invariant) elasticity. The last section concludes.

2. Data and empirical strategy

We use two datasets: (i) *BACI* database on worldwide exports, (ii) *MAcMap–HS6* database on applied bilateral tariffs for the years 2001, 2004, 2007, 2010, 2013 and 2016. Gravity control variables introduced in the estimations (such as distance and common colony) come from CEPII gravity database.

2.1. FOB imports in BACI

For a full matrix of importer and exporter countries, we use the BACI database: it provides information on bilateral trade flows (FOB), in current US Dollars, over the period 1996-2016 at the HS6 level.²⁴

Based on COMTRADE, BACI has three specific features useful for our exercise. First, BACI is filling empty cells in the world trade matrix using mirror trade flows. Second, BACI is reconciling reported values between exporter i and importer j for a given product category k and year t pair: one can indifferently use exports $X_{i,j,k,t}$ or imports $M_{j,i,k,t}$ which are identical.²⁵ Third and importantly, BACI is providing import values net of transport costs (hence FOB): transport and insurance rates were estimated regressing the observed CIF/FOB ratio for a given flow on gravity variables and a product-specific world median unit value.²⁶ Using FOB values of imports matters for the structural interpretation of the estimated tariff elasticity: the tariff is not included in the value paid by the importer. See section 2.4 for a detailed discussion on this point.

²⁴See Gaulier & Zignago (2010) concerning the documentation of this database of from CEPII.

²⁵The reliability of reporting countries is used as weight to reconcile bilateral trade flows.

²⁶BACI is freely available online. See http://www.cepii.fr/CEPII/fr/bdd_modele/presentation.asp?id=1.

2.2. MAcMap-HS6 tariffs

To estimate the elasticity of import values to tariffs we need information on bilateral applied tariffs for all importers and exporters and all products. This information is provided by MAcMap-HS6.²⁷ For each product and each country pair, MAcMap-HS6 provides the applied tariff inclusive of ad valorem equivalents of tariff quotas and specific tariffs. The tariff data is available for the years 2001, 2004, 2007, 2010, 2013 and 2016. The methodology is common to the different waves of data. Interestingly, in order to minimize endogeneity problems when computing unit values or when aggregating data, MAcMap-HS6 relies on the method coined as “reference groups” whereby bilateral trade or unit values are replaced by those of a group of similar countries.²⁸ An important feature of the database is that it takes into account specific duties (transformed in ad valorem ones) as well as Tariff Rate Quotas.²⁹ Contingent protection is not included.

2.3. Combining the two databases

MAcMap-HS6 covers 159 importers for the year 2001. Subsequent releases have increased coverage with the exception of year 2010 for which we have only 152 importers. We therefore keep the sample of 152 importers present in all the releases of MAcMap-HS6 (list of importing countries reported in table A1). On the exporting side the constraint is less binding and we keep exporters present in BACI since 2001. Ultimately, we have 189 exporters to 152 destinations in each year. At the HS6 level, the worldwide matrix of bilateral trade comprises a lot of zeros. However, not all these zeros convey useful information for our exercise. If country j does not import product k from exporter i , this might just be due to the fact that i never exports k . In this case, including all the zeros originating from country i in product k

²⁷This version of MAcMap is devoted to analytical purposes (Guimbard, Jean, Mimouni & Pichot 2012). This HS6 information is an aggregation of tariff line level instruments performed by the International Trade Center (ITC, UNCTAD-WTO) and made available to the CEPII.

²⁸Reference groups in MAcMap are built following clustering procedures on GDP per capita and trade openness. This methodology produces large groups of countries sharing similar trade-related characteristics. See Bouët, Decreux, Fontagné, Jean & Laborde (2008) for further details on the foundations of the reference group method.

²⁹Filling rates are used to choose between the inside and outside tariff, when dealing with a tariff rate quota.

across all destinations j would inflate the dataset with useless information.³⁰ We therefore do a fill-in of the world trade matrix only when country i is exporting product k to at least one destination over the period. We then match all the non-zero and zero trade flows with the tariffs $\tau_{i,j,k,t}$. After merging these two datasets, for each of the 5,052 HS6 product categories, we end up with a panel dataset of country pairs for the years 2001, 2004, 2007, 2010, 2013 and 2016. The non-consecutive nature of our dataset allows our dependent variable to adjust in presence of trade policy change i.e. tariff change in our case (Anderson & Yotov 2016).

Let's now depict world protection adopting this systematic approach of bilateral trade flows and tariffs. In table 1 we report the share of each type of tariff in force over the total non-missing importer-exporter-HS6 combinations. The first observation is that the vast majority of non-zero tariffs are ad valorem. Specific tariffs or compound tariffs (combining ad valorem and specific elements on the same tariff line) sum up to around one percent of all non-missing importer-exporter-HS6 observations. However, given the potentially high protection they provide, specific or compound tariffs should not be disregarded. We will keep track of the ad valorem equivalent of these specific or compound tariffs in our calculations. The second observation is that the 2000's correspond to a steady phasing out of tariffs: the share of products (i.e. tariff lines) having tariff equal to zero almost doubled between 2001 and 2004 (from 18% to 31%), up to representing the 40% of non-missing occurrences in 2016. This "zeroing" goes beyond the commitments of the Uruguay Round and mirrors either the phasing out of nuisance tariffs or the phasing-in of new Regional Trade Agreements (RTAs).³¹ These two observations call for a deeper analysis on: i) the coverage of MFN vs preferential tariffs and ii) the respective contributions of the within and between changes in products' bilateral tariffs.

In table 2 we report the share of non-missing importer-exporter-HS6 combinations adopting MFN *versus* preferential tariffs. The entry into force of new RTAs over the last decades,

³⁰More specifically, in this circumstance non-linear estimator (like the PPML adopted here as baseline) does not use this information as the dependent variable would be perfectly predicted by exporter-year fixed effects.

³¹Nuisance tariffs are duties close to zero percent not worth collecting at the border.

Table 1 – Share of the different tariff types for non-missing importer-exporter-HS6 cells

| Year | % of cells with tariff: | | | |
|------|-------------------------|------------|--------------|----------|
| | Per unit | Ad valorem | Zero applied | Compound |
| 2001 | 0.4 | 79.7 | 18.7 | 1.2 |
| 2004 | 0.7 | 68.0 | 31.0 | 0.3 |
| 2007 | 0.7 | 63.4 | 35.6 | 0.3 |
| 2010 | 0.5 | 61.5 | 37.7 | 0.3 |
| 2013 | 0.5 | 59.8 | 39.4 | 0.3 |
| 2016 | 0.6 | 59.0 | 40.0 | 0.4 |

Note: this table reports the share of per unit, ad valorem, compound and zero tariffs in force for non-missing importer-exporter-HS6 combinations. *Source:* MAcMap-HS6, authors calculation.

discussed in detail in Freund & Ornelas (2010), translates into a reduction in the frequency of MFN tariffs. Notwithstanding this slight decline, MFN tariffs remain extraordinary present in world trade, representing three bilateral tariffs out of four on average.

Table 2 – Share of non-missing importer-exporter-HS6 cells with Preferential vs MFN tariff.

| Year | % of cells with: | |
|------|---------------------|------------|
| | Preferential tariff | MFN tariff |
| 2001 | 22.2 | 77.8 |
| 2004 | 20.2 | 79.8 |
| 2007 | 21.7 | 78.3 |
| 2010 | 23.5 | 76.5 |
| 2013 | 25.6 | 74.4 |
| 2016 | 25.6 | 74.4 |

Note: this table reports the share of non-missing importer-exporter-HS6 combinations with respectively preferential and MFN tariff in force. *Source:* MAcMap-HS6, authors calculation.

In order to guide our empirical exercise, it is crucial to characterize the sources of variation of tariffs in our data base. Product level tariffs can vary both within each country pair over time (*within* variation) and/or across trade partners within a given year (*between* variation).³² In table 3, for each HS section, we report the between and within country-pairs variance of

³²The within variation therefore reflects the variability of tariffs over time; while the between variation reflects the heterogeneity of tariffs imposed by different countries in a given year.

applied tariff.³³ Most of the variance takes place between country pairs for each product; we therefore exploit the *between* pairs variation in bilateral tariffs to estimate tariff elasticities in the next section. The contribution of the within variance is not negligible for section XI (corresponding to the phasing out of protection for Textiles and Textile articles). The largest between variation is observed for section IV corresponding to Prepared Foodstuffs, Beverages and Tobacco. The latter sector is also the one exhibiting the highest average protection among all country pairs (16.9 percent in 2016) and the highest variance as well (38.6) as shown in tables A2 and A3 in the Appendix.

Table 3 – Within vs between variation in product level bilateral applied tariffs, by HS section, 2001-2016.

| | | Variance | |
|-------|--|---------------|----------------|
| | | <i>Within</i> | <i>Between</i> |
| I | Live Animals and Animal Products | 0.112 | 0.217 |
| II | Vegetable Products | 0.104 | 0.194 |
| III | Animal or vegetable fats and oils | 0.074 | 0.136 |
| IV | Prepared foodstuffs, beverages and tobacco | 0.159 | 0.259 |
| V | Mineral products | 0.033 | 0.060 |
| VI | Products of chemical industries | 0.038 | 0.061 |
| VII | Plastic and articles thereof | 0.043 | 0.079 |
| VIII | Raw hides and skins, leather and article thereof | 0.051 | 0.104 |
| IX | Wood/Cork and articles of Wood/Cork; | 0.063 | 0.101 |
| X | Pulp of wood or other cellulosic materials | 0.040 | 0.075 |
| XI | Textile and textile articles | 0.100 | 0.116 |
| XII | Footwear, Headgear, Umbrellas and prepared feathers | 0.070 | 0.126 |
| XIII | Articles of stone, plaster, ceramic and glass | 0.045 | 0.100 |
| XIV | Natural cultured pearls and precious stones and metals | 0.050 | 0.109 |
| XV | Base metals and articles of base metals | 0.038 | 0.075 |
| XVI | Machinery and mechanical appliances and electrical machinery | 0.037 | 0.067 |
| XVII | Vehicles, Aircraft and transport equipment | 0.050 | 0.092 |
| XVIII | Optical, photographic, precision and medical instruments | 0.042 | 0.079 |
| XIX | Arms and ammunitions | 0.104 | 0.209 |
| XX | Miscellaneous | 0.053 | 0.108 |
| XXI | Works of art | 0.047 | 0.106 |

Note: To build this table we computed the *within* and *between* variance for each HS6 product. HS6 variances have been then aggregated at the level of HS section by simple average.

³³For each HS6 product we calculated the within and between component of variance in applied tariffs, and aggregated them up (by simple average) at HS section.

2.4. Empirical strategy

To estimate the tariff elasticity for each of the 5,052 HS6 product categories, we rely on a standard structural gravity framework accounting for multilateral resistance terms by using country-time fixed effects. The following empirical model is performed to recover the tariff elasticity at the product level (hence 5,052 times):

$$\text{Import}_{j,i,t} = \theta_{it} + \theta_{jt} + \beta_0 \ln(1 + \tau_{j,i,t}) + \mathbf{1} \mathbf{Z}_{j,i} + \epsilon_{j,i,t} \quad (1)$$

where the tariff elasticity $\beta_0 = -\sigma$ in the usual CES framework, σ being the elasticity of substitution between varieties of HS6 products exported by different countries.³⁴ Equation (1) is performed for each HS6 category of product k . With the product specific tariff elasticity at hand we can recover trade elasticity accordingly, i.e. $\varepsilon = 1 + \beta_0$.³⁵ By estimating equation (1) by HS6 product, we implicitly assume the elasticities attached to other trade costs included in $\mathbf{Z}_{j,i}$ (such as distance, common language, etc.) to be also product specific. This may not be the case. In a robustness check reported in figure A2 we show the distribution of trade elasticities obtained by constraining the elasticity of the other covariates to be constant across products of a given HS 4-digit heading.

In equation 1 we always include exporter-year (θ_{it}) and importer-year (θ_{jt}) fixed effects to fully control for exporter and importer multilateral resistance terms.³⁶ By doing so, and running equation (1) by product category, we exploit the variation in tariffs imposed in different destinations on a given exporter at different points in time.³⁷ Finally, to control

³⁴Since we use FOB import values, the structural interpretation of the coefficient attached to tariffs - $\ln(1 + \tau_{j,i,t})$ - in eq. (1) represents the negative of the elasticity of substitution σ in a CES framework; while $1 - \sigma$ represents the trade elasticity ε . We obtain a distribution of β_0 centered around -6, so the average trade elasticity in our sample is equal to $\varepsilon = (1 - \sigma) = -5$.

³⁵The final database, available in the CEPII website, contains a variable indicating the trade elasticity for each HS6 position.

³⁶See Head & Mayer (2014) for a complete discussion on how to control for multilateral resistance terms. Note that relying on a strategy of country (or country-time) fixed effects estimated with a PPML is consistent because the sum of fitted export values for each exporter (importer) is equal to its actual output (expenditure) (Fally 2015). This property of the PPML, has been extensively exploited by Anderson, Larch & Yotov (2018) to simulate in full endowment general equilibrium the impact of changes in the trade cost matrix.

³⁷Remember the panel nature of our tariff data available for years 2001, 2004, 2007, 2010, 2013, 2016.

for bilateral specific geographic related trade costs (as derived by a standard gravity model for trade), the set of control variables $\mathbf{Z}_{j,i}$ always includes: (i) distance (in logarithm), (ii) a dummy for common colony, (iii) a dummy for common border and (iv) language.³⁸ To address the heteroskedasticity in the error term (and the zero trade flows problem - missing information), we follow Santos-Silva & Tenreyro (2006) and adopt a PPML estimator as baseline (and preferred) estimator to run equation (1). The distribution of ε obtained using a PPML estimator for each HS6 product is shown in figure 1. The comparison between the distribution of estimated ε obtained by PPML and OLS is reported in figure A1 and illustrates the bias emerging in disregarding the zero trade flow problem with OLS - see section 3.4 for detailed discussion on baseline results.

Beyond the usual third-country effects extensively addressed in the recent literature on structural gravity, a proper identification of the bilateral tariff elasticity β_0 should control for the reaction of third countries $n = 1 \dots N$ (with $n \neq j$) to changes in bilateral tariff τ_{ijt} . Indeed, if a third country $n \neq j$ reacts to a change in the τ_{ij} tariff (e.g. to avoid trade diversion), the change in bilateral trade ij is the results of two channels: (i) the direct effect of the variation in the bilateral tariff τ_{ijt} and, (ii) the indirect effect through the modified relative market access with respect to third country n . Our exporter-year fixed effects θ_{it} also capture the *average* tariff imposed by third countries $n \neq j$ to the exporter country i (i.e. tariff faced by exporter country i , at time t , in exporting to third countries n).³⁹

Considered the inclusion of country-year fixed effects controlling for any unobserved country-year specific factors, and the geographic controls capturing the bilateral transport cost, our estimations present strongly reduced omitted variable concerns. However, it may be the case that a destination experiencing a positive shock in imports of a specific product from a specific exporting country (note that any importer specific shock, such as a demand shock,

³⁸While technically possible, we could not include country-pair fixed effects because of the short time horizon in our panel and the small within variation in tariff. See table 3. This is testified by the huge number of null tariff coefficients (i.e. 3,548 out of 5,052 HS6 products) when country pair fixed effects are included in equation 1.

³⁹This strategy equals the inclusion of the average tariff imposed by third countries $n \neq j$ to exporter i , *Third Country Tariff* $f_{ijt} = \frac{1}{N-1} \sum_{n \neq j}^{N-1} \tau_{int}$, where N is the total number of importing countries $n \neq j$. While this variable appears to be ijt specific, it is a simple combination of the average tariff imposed by third countries n and the bilateral tariff τ_{ijt} . So, the inclusion of exporter-year fixed effects and bilateral tariff subsumes the inclusion of the variable *Third Country Tariff* f_{ijt} .

is captured by fixed effects) may react by increasing its tariff protection. In this case the estimated parameter β_0 (and the consequent ε parameter) may be biased by endogeneity. To address this potential bias we use lagged tariff variable to further reduce any endogeneity concern in section 2.3.1. Given the non-consecutive year nature of our dataset, we can safely argue that the contemporaneous level of imports is less likely to affect tariff imposition three years before. In the Appendix section B we also adopt an Instrumental Variable approach to further reduce any endogeneity concern.

A last concern is the composite nature of trade costs: geography (transport costs, contiguity), tariffs and non-tariff barriers. Our specification controls for distance between exporter and importer, as well as contiguity. The elasticity of transport cost to distance is indeed sector specific, but we rely on an estimation at the product level, which avoids imposing a common transport cost elasticity across products.⁴⁰ An alternative strategy is to perform estimations at the sector level, while pooling all HS products within the sector and hence imposing a common transport cost elasticity within the sector. We perform such estimations to recover elasticities for TiVA and GTAP sectors. Moreover, in a robustness check we estimate trade elasticities by constraining the elasticity of the other covariates to be constant across products of a given HS 4-digit heading (see figure A2).

Non-tariff barriers deserve a deeper discussion for two reasons. First, tariffs and non-tariff barriers may act as substitutes or complements. A country phasing out its tariffs may well tighten the restrictiveness of regulations at the border in order to cushion the competitive pressure of imports (Orefice 2017). Alternatively, certain countries may exhibit a complementarity of the two types of measures – in China applied tariff reductions were associated with the elimination of non-tariff barriers (Imbruno 2016). Second, were these two types of measures at the border set independently, the mere presence of a non-tariff barrier would be an obstacle to increasing imports after a tariff cut. Against this background, one might want to control for the presence of non-tariff barriers, but we know from the literature that related regulatory measures do not necessarily deter trade – certain regulations convey information

⁴⁰In figure A3 we show the distribution of the estimated coefficient on distance from equation 1. In line with Head & Mayer (2014) distance elasticities are distributed around -1.

on the traded products and thus facilitate trade. Hence, introducing a control for the presence of a non-tariff barrier at destination for the considered product is hardly the solution. However, as non-tariff barriers are non-discriminatory (see e.g. the WTO agreement on Sanitary and Phyto-Sanitary measures), their presence can be captured, in an equation estimated at the product level, by an importer-time fixed effect. This is the strategy embraced in this paper.

Finally, considering the increasing importance of preferential bilateral tariffs through Regional Trade Agreements (as reported in table 2 almost one quarter of the applied bilateral tariff are not MFN), in a robustness check discussed in section 3.5.4 we augment eq. 1 by including a dummy for the presence of an active RTA between importing and exporting country. This robustness check avoids that the parameter β_0 in equation 1 reflects the impact of the presence of a RTA.

3. Disaggregated Trade Elasticities

In this section we present the estimated trade elasticity parameters ε obtained for 5,052 products, computed over the period 2001-2016 and considering 152 importers. The median of t -statistics is 3.2, and 78% of the estimated elasticities are statistically significant.⁴¹ We first address the problem of positive trade elasticity when the underlying tariff elasticity β_0 is estimated as *positive* and significant. Then we present evidence on trade elasticity ε based on our baseline specification; and finally we also present the outcome of a series of robustness checks.

3.1. Interpreting positive trade elasticities

We estimate equation 1 for each of the 5,052 HS-6 product lines using PPML estimator. Not surprisingly, not all the estimated tariff coefficients are statistically significant with the same degree of confidence. We also obtain positive β_0 parameters for certain products

⁴¹More precisely, the percentage of statistically significant β_0 is 78%, 72% and 61% at the 10-percent, 5-percent and 1-percent significance level. One can benchmark these results with Kee et al. (2008a) using also HS6 data, although the estimation method and the period (1998-2001 instead of 2001-2016) differ. The corresponding figures are 71%, 66% and 57%. Their median t -stat is identical.

that imply (puzzling) positive trade elasticities ϵ .⁴² Table 4 reports descriptive statistics on the share of positive estimated ϵ parameters statistically significant at 1%. Overall, 2.5% of estimated ϵ significant at the 1% level are positive.⁴³ Such positive and significant ϵ coefficients occur for products concentrated in few very peculiar HS 2-digit chapters. We report in table 4 the HS 2-digit chapters whose frequency of positive ϵ coefficients is above the mean. Organic and inorganic chemicals, Nuclear reactors represent the lion's share in the total number of positive ϵ elasticity.⁴⁴ While in certain sectors, such as Nuclear reactors, deviations from the usual market forces were expected, in other cases, like Chemicals, these positive trade elasticities ϵ deserve further scrutiny. When prices hardly determine quantities, deviations from the perfect competition equilibrium have to be envisaged. But a low degree of competition does not suffice to explain the reversal of the sign of the trade elasticity. We therefore envisage an alternative explanation based on a general equilibrium argument.

⁴²Positive trade elasticity may also be a consequence of small tariff elasticity, i.e. $-1 < \beta_0 < 0$. However this occurs only for one HS6 product.

⁴³The proportion rises to 4.3% and 6% respectively at the 5% and 10% significance level. In the analysis that follows and in the dataset we provide, we keep 1% significant ϵ only. Trade elasticities ϵ associated to non-significant tariff coefficients are reported as zero (as statistically non-different from zero). In the published version of the database, each positive HS6 ϵ coefficient has been substituted by the average ϵ of its HS-4 heading (average across negative HS-6 specific ϵ within HS4). Concerned products are flagged. The database therefore contains four variables: (i) the HS6 product category, (ii) the value of trade elasticity ϵ , (iii) a dummy indicating whether the ϵ coefficient from the original estimation was actually one (i.e. non-significant tariff elasticity), (iv) a dummy indicating whether the ϵ from the original estimation was positive.

⁴⁴The presence of numerous anti-dumping duties for Organic and inorganic chemicals may help explaining this outcome: in presence of a binding overhang, imposing countries may increase their applied tariff up to the bound tariff in order to compensate for the phasing out of the anti-dumping duty, hence generating a simultaneous increase of tariff and imports.

Table 4 – Descriptive statistics of trade elasticity coefficients ε . Number of statistically significant positive trade elasticities $\varepsilon > 0$ due to positive tariff elasticity $\beta_0 > 0$. Total and by HS 2-digit chapter (only HS-2 digit chapters with number of $\beta_0 > 0$ above the mean are reported)

| Chapter | Sector description | Number of $\varepsilon > 0$ |
|--------------|--|-----------------------------|
| Total | | 128 |
| 2 | Meat and edible meat | 2 |
| 3 | Fish And Crustaceans, Molluscs And Other Aquatic Invertebrates | 4 |
| 12 | Oil Seeds And Oleaginous Fruits; Miscellaneous Grains, Seeds And Fruit, Industrial Or Medicinal Plants | 2 |
| 15 | Animal or Vegetable fats and oils and their cleavage products | 2 |
| 26 | Ores, Slag And Ash | 3 |
| 28 | Inorganic Chemicals | 7 |
| 29 | Organic Chemicals | 35 |
| 37 | Photographic Or Cinematographic Goods | 4 |
| 55 | Man-Made Staple Fibres | 2 |
| 62 | Apparel And Clothing Accessories | 3 |
| 63 | Textiles, Made Up Articles; Sets; Worn Clothing And Worn Textile | 3 |
| 65 | Headgear And Parts Thereof | 2 |
| 71 | Natural, Cultured Pearls; Precious, Semi-Precious Stones; Precious Metals | 2 |
| 72 | Iron And Steel | 3 |
| 73 | Iron Or Steel Articles | 3 |
| 81 | Metals; N.E.C., Cermet And Articles Thereof | 2 |
| 82 | Tools, Implements, Cutlery, Spoons And Forks, Of Base Metal | 3 |
| 84 | Nuclear Reactors, Boilers, Machinery And Mechanical Appliances; | 14 |
| 85 | Electrical Machinery And Equipment And Parts Thereof | 3 |
| 87 | Vehicles; Other Than Railway Or Tramway Rolling Stock | 2 |
| 90 | Optical, Photographic, Cinematographic, Measuring, Checking, Medical Or Surgical Instruments And Apparatus | 2 |
| 91 | Clocks And Watches And Parts Thereof | 4 |
| 96 | Miscellaneous Manufactured Articles | 2 |

Note: This table reports descriptive statistics on estimated trade elasticities $\varepsilon = 1 + \beta_0$ (as in equation 1) when β_0 positive and statistically significant. For only one product (HS6 151011) we obtain positive trade elasticity with negative tariff elasticity (i.e. $-1 < \beta_0 < 0$).
Source: Authors' calculation.

Let us focus first on market structures as explanation for positive elasticity ε . Although the occurrence of positive trade elasticities represent only the 2.5% of the total sample of significant elasticities, we want to provide a characterization of the product categories where this problem appears. To this end we adopt a purely heuristic approach and run a probit model aimed at explaining the probability of having positive trade elasticity (when underlying tariff coefficient is positive) - $\mathbb{P}[\varepsilon_k > 0 | \beta_0 > 0]$ - using proxies of market structures:

$$\mathbb{P}[\varepsilon_k > 0 | \beta_0 > 0] = \gamma_1 \mathbf{X}_k + \gamma_2 \mathbf{M}_k + \gamma_3 \mathbf{X}\mathbf{M}_k + \gamma_4 \mathbf{K}_k + \varepsilon_k \quad (2)$$

In equation (2) the probability of obtaining a positive and significant (at 1%) trade elasticity for a given product k from equation (1) depends on three sets of covariates: (i) exporters' characteristics in the international trade of product k (\mathbf{X}_k); (ii) importers' characteristics (\mathbf{M}_k); (iii) country-pairs characteristics in the international trade of product k ($\mathbf{X}\mathbf{M}_k$); and (iv) on product specific characteristics (\mathbf{K}_k). Namely, the set of covariates \mathbf{X}_k includes the number of exporting countries in a specific k , their concentration (measured with Herfindahl-Hirschmann index), and the average per capita GDP (weighted by total exports) of the exporter - here intended as a proxy for the technical level/quality of the exported products. Symmetrically, the set of covariates \mathbf{M}_k includes the same variables but from the perspective of the importing countries. The set of covariates $\mathbf{X}\mathbf{M}_k$ includes the number of bilateral zero-trade flows, and the average distance covered by a product in its international trade matrix tentatively accounting for sorting effects in relation with trade costs.⁴⁵ Finally, the set of product specific covariates \mathbf{K}_k includes a dummy for differentiated vs homogeneous products and importantly the average HS 4-digit applied worldwide bilateral tariff.⁴⁶

Results reported in table 5 confirm regularities explaining the observed deviation from the perfect competition equilibrium for certain product categories. First, products k with a highly

⁴⁵We consider here the average distance across country-pairs in a given products k , weighted by trade flows. Since the estimated elasticity ε does not vary over time, all the explanatory variables have been expressed as average over the time period.

⁴⁶Given that the big chunk of positive trade elasticities belongs to the sector of nuclear reactors (HS 84), we replicated the estimation of equation 2 excluding the HS chapter 84 and results do not change.

concentrated set of exporters and/or importers (as revealed by HH index) are more likely to show positive tariff elasticity and therefore trade elasticity ε . In presence of a high market concentration, a reduction in tariffs imposed on a market may lead to unexpected results: an increase in the degree of competition at destination may push the incumbent exporters to exert an even higher effort in securing their presence at destination. In a model of imperfect competition and variable markups, firms decrease their markups and thus export prices when they lose market share (Atkeson & Burstein 2008). This translates in a negative relationship between tariffs and export price (see Fontagné et al. 2018), which partially offsets the direct negative tariff effect on exports (though it would not reverse the sign of the estimated elasticity). A second interesting regularity emerging from table 5 is the positive correlation between the average income of exporters and importers and the probability of obtaining positive trade (and tariff) elasticity. Products traded by relatively high-income countries show higher probability of having positive trade elasticity. On the exporter side this mirrors the technological level of goods, while the importing side echoes the recent literature on non-homothetic preferences (Markusen 2013) whereby markups are increasing in the destination income per capita (Bertoletti, Etro & Simonovska 2018). But again, this would not explain the positive impact of tariffs on demand for a given quality of the imported good. Some unobserved general equilibrium effect must be at play. In order to address this issue, we observe the impact of tariffs on other goods within the same broad category. We obtain a positive (although weakly significant) coefficient attached to the average HS 4-digit tariff: when the tariff associated to another similar product $s \neq k$ increases (here captured by the average tariff in the HS4 chapter), imports of j may rise even in presence of higher j 's import tariff as a consequence of the substitution of j with s .

3.2. Interpreting non-significant trade elasticities

The same proxies for market structures used to estimate equation 2 may also explain the presence of non-significant tariff coefficients. In columns 3-4 of table 5 we show results of equation 2 where the dependent variable is the probability of having a non-significant underlying tariff elasticity, i.e. $\mathbb{P}[\beta_0 = 0]$.

Columns (3)-(4) of table 5 show a positive correlation between the probability of obtaining non-significant tariff elasticity and the average income of exporting and importing countries. Similarly, we obtain a positive correlation between the average distance covered by a product and the probability of observing non-significant tariff elasticity. Although these results are coherent with the idea that high-quality products are often characterized by low elasticity of substitution (Hummels & Skiba 2004) they might also be driven by a statistical problem: developed countries have low tariffs on average and little variation in these tariffs, making it difficult to estimate the coefficient of interest on tariffs. Also, in line with the intuition, from columns (3)-(4) it emerges that demand for differentiated products is likely to be hardly sensitive to tariffs, as illustrated here by the positive and significant impact of differentiation on the probability of getting a non significant β parameter estimate on the tariff variable in our baseline equation. Finally, columns (3) and (4) of table 5 illustrate the intrinsic difficulties of trade elasticity estimation based on tariff variation. First, we observe that the presence of zero trade flows for a given product increases the probability of a non significant β estimate. This is suggestive of unobserved trade barriers making it difficult to assess the impact of trade costs on trade flows based on tariffs and distance (an other controls in Z_{ij}) only. Second, the probability of obtaining a non significant β decreases in the number of exporting countries of a given product. This perfectly makes sense as we are exploiting the variation in the bilateral tariff imposed by importers on the different exporters of the product: other things being equal, the variation in the tariff is expected to increase in the number of exporters, making it easier to estimate precisely the parameter of interest. Third, it is also slightly more difficult to estimate β for HS4 with high tariffs, plausibly because these products are also protected by other trade barriers than tariffs. Notwithstanding these intrinsic obstacles of the method, our estimations perform rather well and we can now focus on the correctly estimated elasticities.

Table 5 – Probit regression on the probability of obtaining: (i) positive trade elasticity (when positive tariff elasticity); (ii) non-significant trade elasticity.

| Dep var: | $\mathbb{P}[\varepsilon_k > 0 \beta_0 > 0]$ | | $\mathbb{P}[\beta_0 = 0]$ | |
|--|---|---------------------|---------------------------|----------------------|
| | (1) | (2) | (3) | (4) |
| Concentration exporters (HH index) | 1.217*** (0.382) | 1.519*** (0.472) | -0.274 (0.250) | -0.349 (0.268) |
| Concentration importers (HH index) | 2.126*** (0.600) | 2.139*** (0.687) | 0.243 (0.384) | 0.107 (0.408) |
| Average per capita GDP exporters (ln) | 0.260** (0.121) | 0.256* (0.144) | 0.0608 (0.0638) | 0.167** (0.0716) |
| Average per capita GDP importers (ln) | 0.565*** (0.179) | 0.521** (0.209) | 0.275*** (0.0818) | 0.220** (0.0965) |
| Average distance across country-pairs (ln) | 0.183 (0.139) | 0.123 (0.164) | 0.645*** (0.0750) | 0.628*** (0.0829) |
| Number of zero-trade flows (ln) | 4.834** (2.434) | 5.861* (3.250) | 8.869*** (1.135) | 8.997*** (1.250) |
| Number of exporting countries (ln) | -4.770** (2.319) | -5.468* (3.107) | -9.148*** (1.058) | -9.222*** (1.166) |
| Number of importing countries (ln) | -34.42 (42.56) | 27.09 (64.31) | -10.93 (24.52) | -24.11 (29.91) |
| Differentiated | -0.0189 (0.121) | 0.117 (0.170) | 0.229*** (0.0553) | 0.207*** (0.0755) |
| Average HS4 tariff | 3.828** (1.796) | 5.084* (2.955) | -0.113 (1.003) | 2.489* (1.471) |
| HS 1-digit Fixed effects | yes | no | yes | no |
| HS 2-digit Fixed effects | no | yes | no | yes |
| Observations | 3,930 | 2,925 | 4,339 | 4,301 |

Note: Dependent variable in columns 1-2 is a dummy equal to one if the estimated trade elasticity $\varepsilon = 1 + \beta_0$ in equation 1 is positive and significant at 1% level with underlying positive tariff elasticity. Dependent variable in columns 3-4 is a dummy equal to one if the estimated trade elasticity $\varepsilon = 1 + \beta_0$ in equation 1 is not statistically significant at 1% level (because not statistically significant tariff elasticity). Robust standard errors in parentheses. *** $p < 0.01$; ** $p < 0.05$; * $p < 0.1$. The number of observations decreases across specifications 1 and 2, 3 and 4, because the inclusion of HS 1-digit and 2-digit fixed effects implies the drop of chapters and sectors having only negative trade elasticity (i.e. $\mathbb{P}[\varepsilon_k > 0 | \beta_0 > 0] = 0$) in all k within a HS1 and HS2 chapter) or always non-null.

3.3. Explaining the magnitude of trade elasticity

This section explores some regularities in the magnitude of the estimated trade elasticity $|\epsilon|$.⁴⁷ Results reported in table 6 show two clear-cut results. First, as expected the magnitude of trade elasticity is smaller for differentiated products. Second, after controlling for the HS 2-digit chapter, products covering (on average) wider distance in the bilateral-trade matrix have a smaller trade elasticity.⁴⁸ Indeed, these are products traded in spite of a large trade cost (as reflected by distance) and thus plausibly less elastic to shocks in tariffs.

Table 6 – OLS regression on the absolute value of trade elasticity.

| Dep var: | $ \epsilon_k $ | |
|--|----------------------|----------------------|
| | (1) | (2) |
| Average distance across country-pairs (ln) | -0.786 (0.566) | -1.594*** (0.606) |
| Differentiated | -6.493*** (0.450) | -4.899*** (0.600) |
| HS 1-digit Fixed effects | yes | no |
| HS 2-digit Fixed effects | no | yes |
| Observations | 2,518 | 2,518 |

Note: Dependent variable in columns 1-2 is the absolute value of trade elasticity when negative ($\epsilon < 0$ with $\beta_0 < -1$). Robust standard errors in parentheses. *** $p < 0.01$; ** $p < 0.05$; * $p < 0.1$.

3.4. Baseline results

The empirical distribution of significant trade elasticities ϵ , after excluding positive ones, is centered around -5 as shown in figure 1 and can be very large for certain products (beyond -20).⁴⁹ Trade elasticities ϵ are more dispersed in the manufacturing industry than in agriculture, but centered around the same value (see Appendix figure A4). An important question is the sensitivity of the estimated elasticities to the estimator used. By comparing the trade

⁴⁷We use the absolute value of trade elasticity to ease the interpretation of results and restrict to negative and statistically significant tariff elasticities.

⁴⁸Results reported in table 6 are correlations and cannot be interpreted as causal.

⁴⁹The average trade elasticity after excluding product with positive tariff elasticity is -5.5. The empirical distribution reported in figure 1 does not consider products with positive or non-significant tariff elasticities. The left tail of the empirical distribution reported in Figure 1 has been cut at -25 to the sake of readability of the figure. However only for a very few number of HS6 products (3% of total product lines) we obtain even larger trade elasticities.

elasticity distribution between PPML and OLS estimator, we find that the zero trade flows problem (and heteroskedasticity) and the different weighting scheme in the two estimators imply a severe negative bias in the magnitude of trade elasticity ϵ (compare continuous with dash line in figure A1). To isolate the role of the different weighting scheme between the two estimators, the dotted line in figure A1 reports the trade elasticity distribution obtained by employing PPML on a dataset without zero-trade flows (remember that the OLS never include zero-trade flows). The comparison between the latter and the OLS distribution of ϵ reveals a negative bias in the estimation of trade elasticities due to the different weighting scheme between the two estimators. Another interesting characterization of trade elasticities ϵ by type of product emerges by using Rauch classification on differentiated vs homogeneous products. As expected, figure A5 shows bigger and more dispersed ϵ coefficients for homogeneous than for differentiated products (this is also in line with the evidence discussed above on manufacturing vs agriculture products).

As said, our method does not allow us to estimate the whole set of trade elasticities. Indeed, for some HS-6 digit positions, the bilateral variability in tariff is not sufficient to estimate the parameter β_0 in equation 1. Table 7 shows, for each HS section, the number of HS6 positions and the number of estimated elasticities ϵ . In most of the sectors, the method is successful. In 5 sections of the HS, all β_0 elasticities are estimated. For Pulp of wood or other cellulosic materials, only two product level elasticities are not identified out of 144 product categories; the same observation can be made for Articles of stone, plaster, ceramic and glass (respectively 1 out of 143). One sector is more problematic (Products of chemical industries): here, only 729 β_0 coefficients are estimated out of 789 product categories.⁵⁰

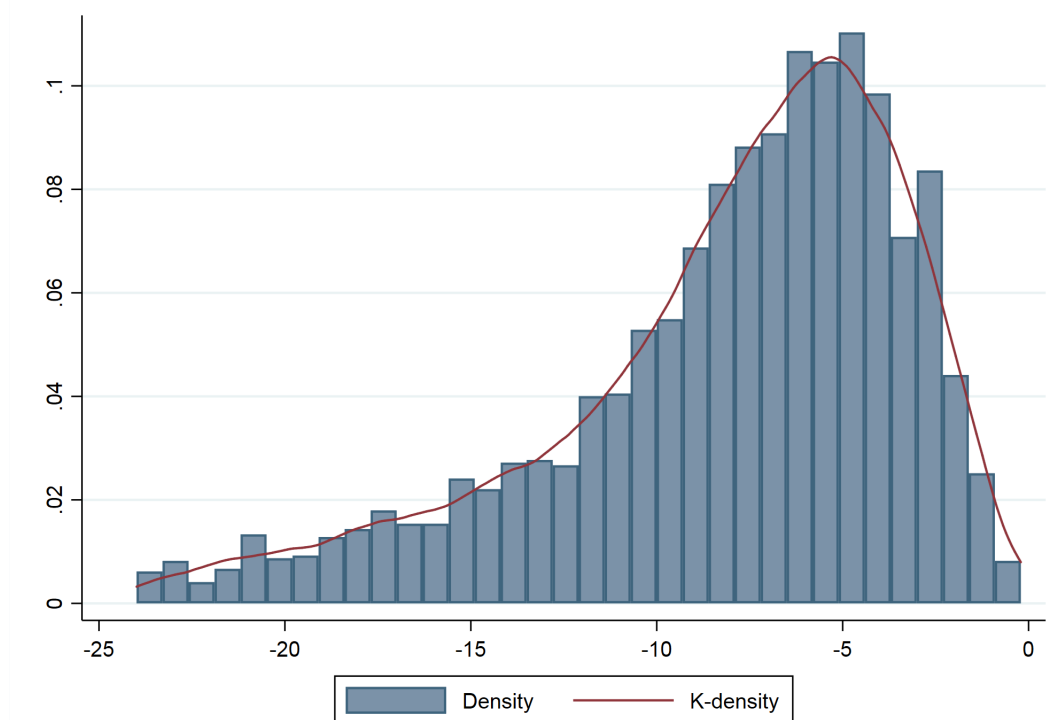
The average trade elasticities ϵ within the different Sections of the HS (average of the product level trade elasticities within the Section) exhibit values in line with the expectations: for rather standardized products like Plastic and Rubber the average trade elasticity is close to -9 (which corresponds to a tariff elasticity of -10), while in highly differentiated products like Footwear this is -4.7. The largest trade elasticities (“min” in the table) can reach very

⁵⁰Descriptive statistics on trade elasticity ϵ by HS section reported in table 1 do not consider products with positive elasticity ϵ .

high values. Some of these may be considered outliers in estimations but are anyway kept in the database.⁵¹

The dispersion of estimated trade elasticities ε within a sector can be further illustrated by focusing on the sector – Textile – comprising the largest number of HS6 categories.⁵² The average dispersion across the 788 estimated trade elasticities ε (out of 801 product categories) is -8.36. We show in table 8 the average trade elasticities by HS2 within the Textile industry. The trade elasticity ε is very large for Man-made filaments or Man-made staple fibres (respectively -10.69 and -10.55) and much lower for Apparel and clothing accessories not knitted or crocheted, for Textile, made up articles, sets, worn clothing and worn textile articles and Apparel and clothing accessories knitted or crocheted (respectively -5.02, -4.53, -3.00).

Figure 1 – Empirical distribution of trade elasticity ε across all products (PPML estimations)



Source: Authors' calculations. Note: empirical distribution calculated on HS-6 products with $\varepsilon < 0$.

⁵¹The maximum estimated elasticity is equal to 123 for product code "270210", which is even below the elasticity obtained by Broda and Weinstein for the HS 3-digit product heading "860" or "021".

⁵²For the clarity of exposition, we keep textile as an example. However product specific trade elasticities are highly heterogeneous in all the products categories. Descriptive statistics on trade elasticity for textile products do not consider products with positive elasticities ε .

Table 7 – Descriptive statistics of trade elasticities by HS section

| Section | Description | Average | Std Dev | Min | N. of HS6 | N. of HS6 non-missing ϵ |
|---------|--|---------|---------|---------|-----------|----------------------------------|
| I | Live Animals and Animal Products | -9.88 | 10.00 | -70.55 | 228 | 221 |
| II | Vegetable Products | -6.93 | 4.57 | -37.51 | 256 | 248 |
| III | Animal or vegetable fats and oils | -10.23 | 9.29 | -46.70 | 45 | 43 |
| IV | Prepared foodstuffs, beverages and tobacco | -6.55 | 4.47 | -29.19 | 193 | 193 |
| V | Mineral products | -23.44 | 19.23 | -122.97 | 148 | 141 |
| VI | Products of chemical industries | -13.32 | 11.72 | -117.08 | 789 | 729 |
| VII | Plastic and articles thereof | -9.30 | 7.27 | -63.41 | 211 | 211 |
| VIII | Raw hides and skins, leather and article thereof | -7.65 | 4.54 | -20.20 | 69 | 66 |
| IX | Wood/Cork and articles of Wood/Cork; | -10.12 | 8.55 | -61.96 | 93 | 93 |
| X | Pulp of wood or other cellulosic materials | -11.09 | 7.41 | -62.82 | 144 | 142 |
| XI | Textile and textile articles | -8.36 | 7.11 | -51.42 | 801 | 788 |
| XII | Footwear, Headgear, Umbrellas and prepared feathers | -4.75 | 2.52 | -10.67 | 49 | 46 |
| XIII | Articles of stone, plaster, ceramic and glass | -7.57 | 4.00 | -21.26 | 143 | 142 |
| XIV | Natural cultured pearls and precious stones and metals | -19.44 | 15.29 | -68.81 | 51 | 49 |
| XV | Base metals and articles of base metals | -11.51 | 10.41 | -67.13 | 568 | 556 |
| XVI | Machinery and mechanical appliances and electrical machinery | -7.98 | 5.86 | -38.17 | 769 | 748 |
| XVII | Vehicles, Aircraft and transport equipment | -12.62 | 8.66 | -40.58 | 131 | 128 |
| XVIII | Optical, photographic, precision and medical instruments | -7.96 | 5.97 | -45.94 | 217 | 208 |
| XIX | Arms and ammunitions | -10.70 | 4.30 | -13.65 | 20 | 20 |
| XX | Miscellaneous | -5.87 | 3.23 | -14.39 | 118 | 116 |
| XXI | Works of art | -9.97 | 3.03 | -12.18 | 7 | 7 |

Note: This table reports descriptive statistics (mean, standard deviation, min and non-missing value) on ϵ parameter estimated as in equation 1, for each HS section. Descriptive statistics reported in columns 1-3 are calculated considering only HS-6 products having $\epsilon < 0$ (i.e. excluding HS-6 products with non-significant or positive tariff elasticity).

Source: Authors' calculation.

Table 8 – Descriptive statistics of trade elasticities ε for Textile sector by HS 2-digit chapter.

| Chapter HS 2-digit | Average | Std Dev | Min | # HS-6 with $\varepsilon < 0$ |
|--|---------|---------|--------|----------------------------------|
| Silk | -9.69 | - | -9.69 | 1 |
| Wool, Fine or Coarse Animal Hair; Horsehair yarn and woven | -20.10 | 12.55 | -51.42 | 28 |
| Cotton | -10.04 | 6.72 | -27.86 | 93 |
| Vegetables textile fibres | -18.24 | 11.63 | -40.49 | 11 |
| Man-made filaments; strips and like of man-made textile materials | -10.69 | 8.12 | -48.86 | 56 |
| Man-made staple fibres | -10.55 | 6.14 | -31.79 | 76 |
| Wadding, felt and nonwovens, special yarns; Twine, cordage ropes and cables | -7.43 | 3.08 | -14.47 | 26 |
| Carpets and other textile floor coverings | -5.44 | 2.85 | -12.14 | 12 |
| Fabrics; special woven fabrics, tufted textile fabrics, lace, tapestries, trimmings, embroidery | -5.95 | 3.24 | -16.85 | 23 |
| Textile fabrics; impregnated, coated, covered or laminated; textile articles of a kind suitable for industrial use | -9.18 | 6.28 | -24.77 | 20 |
| Fabrics; knitted or crocheted | -5.71 | 1.29 | -8.77 | 38 |
| Apparel and clothing accessories; NOT knitted or crocheted | -5.02 | 2.34 | -13.18 | 75 |
| Apparel and clothing accessories; knitted or crocheted | -3.00 | 1.86 | -8.84 | 59 |
| Textile , made up articles; sets; worn clothing and worn textile articles | -4.53 | 2.24 | -8.66 | 33 |

Note: This table reports descriptive statistics (mean, standard deviation and min) on ε estimates based on tariff elasticities as in equation 1, for each HS 2-digit chapter within section XI. Descriptive statistics reported in this table are calculated considering only HS-6 products having $\varepsilon < 0$ (i.e. excluding HS-6 products with non-significant or positive tariff elasticity), whose number of reported in the last column.

Source: Authors' calculation.

3.5. Robustness checks

We now perform a series of robustness checks (i) addressing the panel versus cross-section identification strategies; (ii) addressing the endogeneity of tariffs; (iii) quantifying the usual aggregation bias by estimating trade elasticities at different levels of detail of the product classification; (iv) controlling for the presence of an active Regional Trade Agreement (RTA) between exporter i and importer j ; and (v) trying to address the potential selection problem in estimating eq. (1).

3.5.1. Panel versus Cross-section estimations

Considering the small within variation in tariffs (see table 3), our baseline identification strategy relies on the cross-country variation in import tariff (for a given importer-year-product). Such strategy exploits the panel dimension of the bilateral trade and tariff data in order to be fully consistent with a structural gravity approach. Accordingly, our baseline equation is estimated for each product, on the whole period considered here, and including exporter-time and importer-time fixed effects. This strategy raises two issues addressed in this sub-section. First, one may ask whether trade elasticities are stable over time. The pre- and post-2008 trade crisis might correspond to different elasticity patterns; or (more generally) tariff elasticity may not be constant over time. In order to address this first issue we estimate our set of elasticities for these two sub-periods, keeping the specification as for our baseline results, and restrict our attention to a sector where much variation in tariffs is observed: we will consider the extreme case of textile.

The second issue relates to the preferable approach to estimate trade elasticity (panel vs cross-section). Would elasticities estimated in repeated cross sections be, on average, consistent with elasticities obtained by sticking to the panel dimension of the data? Would it make sense to rely on cross-sectional estimations of elasticities in sectors where the within variation of tariffs is important? Indeed, as said, for some HS sections such as textile (HS section XI), vegetable products (HS section II) and prepared foodstuff (HS section IV) there is a non-negligible time variation in tariffs (within component). So, to answer the latter

question, we will consider the extreme case of textile.

We address the first issue by focusing on HS6 products belonging to the textile section XI. In figure 2 we correlate product-level trade elasticities obtained by estimating equation 1 on the sub-period 2001-2007 (horizontal axis) with those obtained using the period 2010-2017 (vertical axis). With some exceptions, observations lie around the 45 degree line (with correlation index 0.74) showing that our methodology is qualitatively insensitive to the time period used. Elasticities estimated by exploiting the panel dimension of the data are hardly sensitive to the period considered.

In order to address the second issue, we adopt a repeated cross-section approach and estimate equation 1 for each (product and) year separately, adjusting accordingly our structure of fixed effects.⁵³ In figure 3 we correlate the baseline elasticities obtained by estimating equation 1 on a panel dataset (as described in section 2.4) with the average elasticity (across years) obtained using the cross-sectional approach. Although (as expected) the correlation is strongly positive, with the majority of product elasticities lying around the 45 degree line, for a considerable amount of products (in particular in the mineral and chemical sectors HS chapters 26, 27 and 29 respectively) the trade elasticities obtained with the two approaches differ considerably.

We finally focus again on the HS 2-digit chapter composing the textile section XI in figure 4. The box plot displays boxes bordered at the 25th and 75th percentile of the time distribution of (average) HS 2-digit trade elasticity, along with the median line and whiskers corresponding to min and max elasticity. From figure 4 it clearly emerges a big gap in trade elasticities estimated in cross-section at different points in time (see for example Wool and Vegetable Textile sectors).

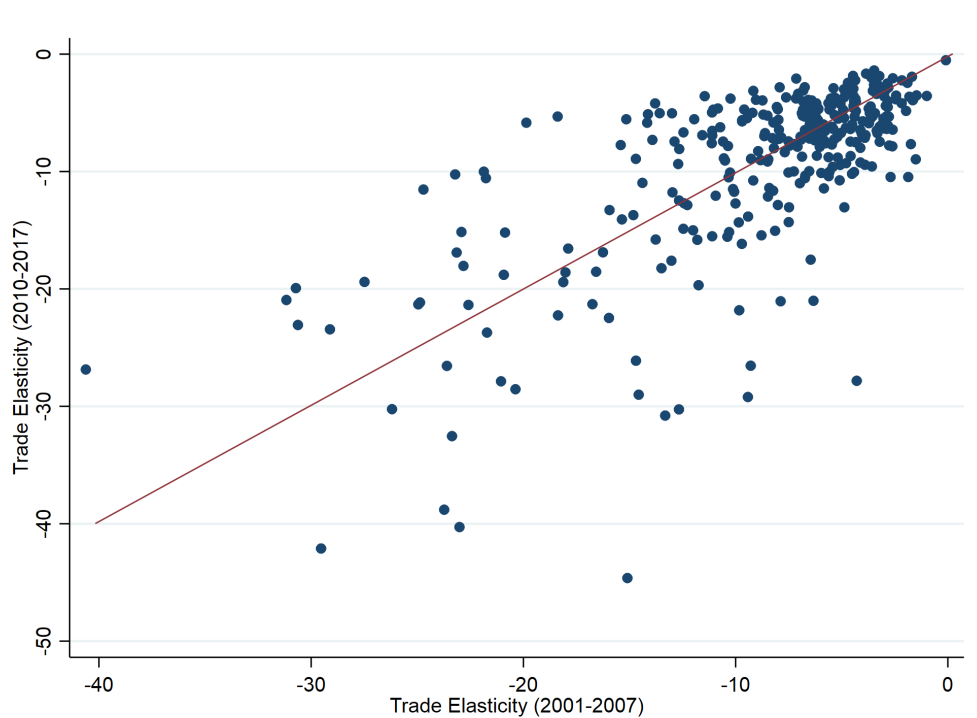
The evidence showed in figures 3 and 4 points to the fact that although the two empirical approaches produce on average qualitatively similar results, there are noticeable exceptions.

This indeed reflects the fact that the $Cov(X_{jit} - X_{jt}, Y_{jit} - Y_{jt})$ computed on a panel

⁵³Namely, we adapt and replicate equation 1 for each product and year (for years 2001, 2004, 2007, 2010, 2013 and 2017). Considered the cross-section nature of this estimations, we always include exporter and imported fixed effects only.

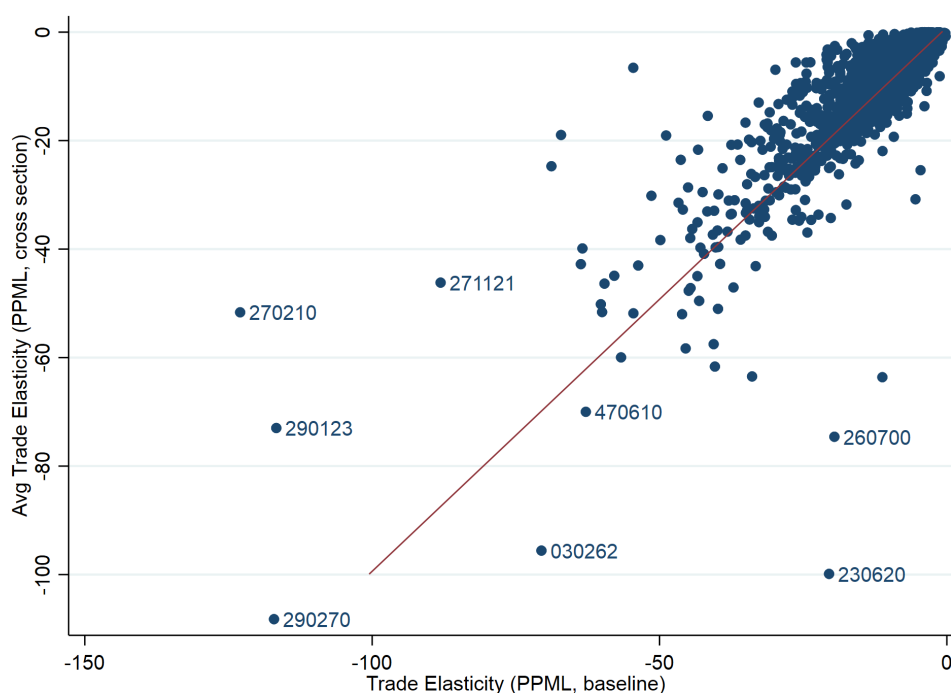
data with the structure of fixed effects as in eq.1 is different from the *average* $Cov(X_{ji} - X_j, Y_{ji} - Y_j)$ computed on year-specific data. From a structural interpretation point of view, such exceptions stress the fact that the cross-section approach, by abstracting the time dimension, does not properly capture any exporter (or importer) specific time varying shock. For this reason the baseline panel approach has to be preferred and we stick to it in the rest of the paper.

Figure 2 – Correlation between baseline HS6 trade elasticity estimated using 2001-2007 vs 2010-2017 sub-period (textile sector, HS section XI).



Source: Authors' calculations. Note: empirical distribution calculated on HS-6 products with $\epsilon < 0$. Trade elasticity values smaller than -50 not reported for readability.

Figure 3 – Correlation between baseline trade elasticity estimations (PPML, panel) and the trade elasticity obtained by averaging HS6 elasticity across years (PPML, cross section)



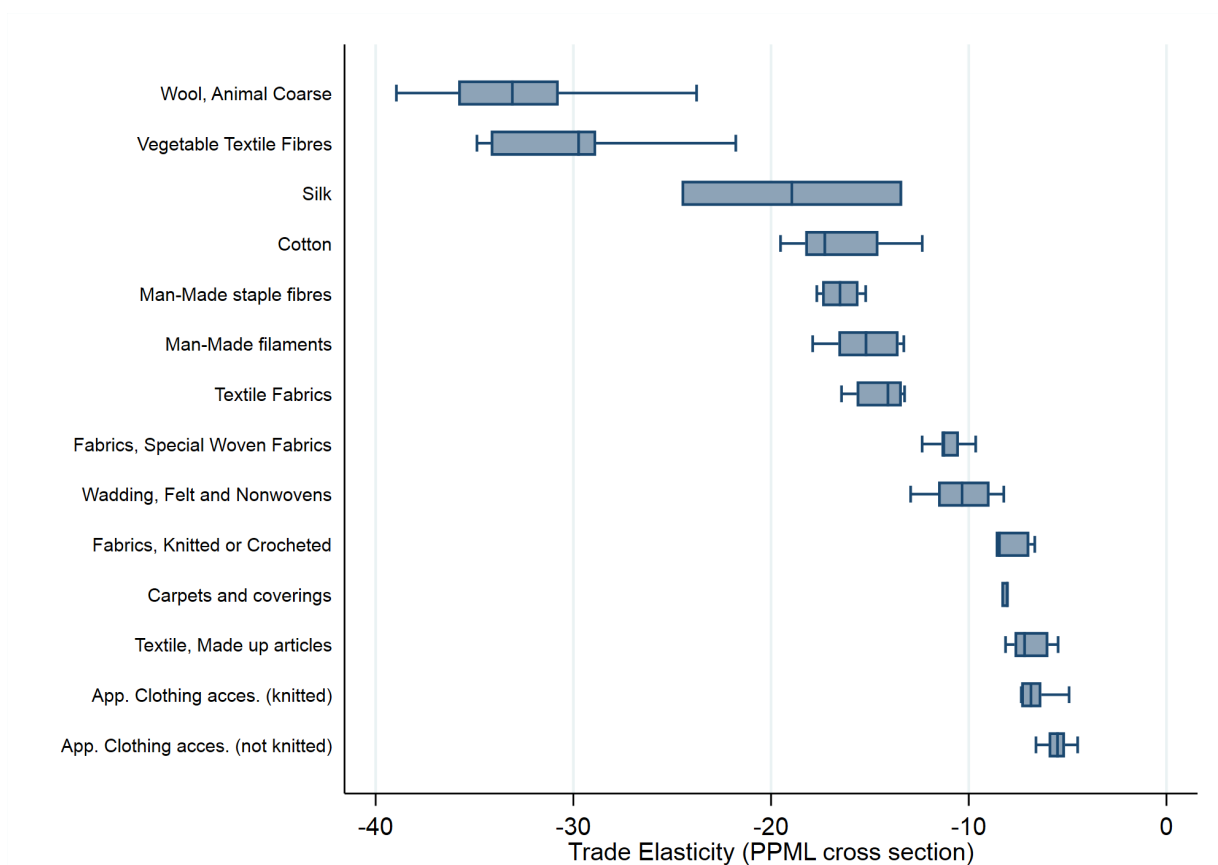
Source: Authors' calculations. Note: empirical distribution calculated on HS-6 products with $\varepsilon < 0$.

3.5.2. Endogeneity

We already mentioned the issue of endogeneity. Technically, two problems of endogeneity have to be addressed when it comes to evaluating the response of trade to tariff shocks. First, since liberalization episodes generally start by lowering tariffs for products or industries hardly affected by foreign competition, tariff cuts may have limited effect. As discussed in the previous section, the inclusion of country-year fixed effects controlling for any unobserved country-year specific factors, and the geographic controls capturing the bilateral transport cost reduce considerably this omitted variable problem. Recall also that estimations are performed at the product level, meaning that the country-year characteristics so controlled pertain to products or industries, as needed.

The second problem is that higher tariffs opposed to certain exporting countries in certain sectors may aim to extract rents from an exporter exerting a high market power, which brings us back to the discussion of market structures above. The political economy of protection also provides a rationale for endogenous tariffs: domestic industries affected by an increasing

Figure 4 – Time variation in trade elasticity by HS 2-digit chapters of the textile sector (HS section XI)



Source: Authors' calculations. Note: for each HS 2-digit chapter the borders of the box represent the 25th and 75th percentile in the time distribution of the HS 2 specific trade elasticity (obtained by averaging HS6 specific elasticities within a HS2). Whiskers correspond to min and max respectively. These statistics are calculated on HS-6 products with $\varepsilon < 0$.

competition of imports will lobby for protection. Accordingly, tariffs should vary with the inverse penetration ratio and price elasticity of imports (Gawande & Bandyopadhyay 2000). The associated reverse causality may potentially bias estimations of β_0 in eq. 1. If an importing country sets the level of tariff protection based on the level of imports from a specific exporter, imports and tariff may show up as *positively* correlated at the detailed level of the product-partner.

At the level of detail considered here (HS6 products), the penetration ratio is not observable as we do not have information on expenditures in the importing country. This excludes any instrumentation method based on this usual theoretical argument and one can resort on lagged variables in line with Shapiro (2016), who estimates trade elasticities for 13 sectors using shipping costs (not trade policy). In figure A6 we finally compare our baseline PPML trade elasticity estimations with those obtained by using three-year lag tariffs.⁵⁴ The distributions of trade elasticities ε using contemporaneous and lagged tariffs do not differ considerably which reinforces the conclusion that the usual endogeneity issue due to the potential reverse causality problem does not invalidate our results.

Alternatively, an instrumentation strategy could be contemplated, whereby one would instrument bilateral tariff with the average tariff imposed by other importing countries on a given exporter-product. Different criteria of selection of the latter countries could be used, such as countries belonging to the same continent or alternatively countries belonging to the same reference group of MAcMap. The drawback of this IV is that it would be highly collinear with the exporter-year fixed effects. Thus for several HS6 products the IV would not be powerful in explaining τ_{ijt} (first stage not significant) and would produce statistically insignificant β_0 parameter. Although this problem cannot be circumvented, we exemplify such instrumentation in Appendix B. As Instrumental Variable for bilateral tariff we use the average tariff imposed by third country $n \neq j$ within the same continent of importer j on a given exporter i at time t . The average trade elasticity obtained by the 2SLS estimations is qualitatively the same as that obtained by PPML estimations: *on average* reverse causality

⁵⁴Remember that MAcMap-HS6 provide tariff data in years 2001, 2004, 2007, 2010, 2013 and 2016.

does not smooth the estimated elasticity to tariff β_0 .⁵⁵

3.5.3. Product aggregation

To what extent are estimated elasticities sensitive to product aggregation? We used here HS6 import and tariff data in order to maximise the variation in tariffs, but it is important to see what this choice implies. In figure A7 we replicate the exercise discussed in section 2.4 but using HS 4-digit rather than 6-digit specific data to estimate the trade elasticity ϵ . Namely, we aggregated imports by summing across HS6 within HS4 positions for each country-pair; we use the simple average tariff at the HS4 level for each importer-exporter pair.⁵⁶ Trade elasticities ϵ at the HS4 level reported in figure A7 show the same empirical distribution as baseline results in figure 1. We also replicate the same exercise and estimated the trade elasticities by HS 2-digit chapter (summing imports and averaging tariffs across HS-6 within HS 2-digit chapter). Results, reported in figure A8 show a less dispersed distribution of trade elasticities distributed again around the same value (about -5). This supports the idea of absence of aggregation bias in trade elasticity. To further support the absence of aggregation bias, in table A4 we report the ratio between trade elasticity calculated at HS6 and respectively HS 4-digit and 2-digit level (average across products within each HS 1 chapter). Ratios suggest again the absence of any systematic aggregation bias. To sum up our argument, using detailed bilateral trade and tariff data is useful because it maximises the variation in tariffs and hence makes the estimation of elasticities more precise, and because we maximise the variance in elasticities across products, but this methodological choice does not imply a systematic upward bias in the estimated elasticities.

In order to compute gains from trade à la Arkolakis et al. (2012) reported in section 3, we also have to estimate tariff (and therefore trade) elasticities using the TiVA sector aggregation. In this case, rather than summing imports and averaging tariffs across HS-6 within each TiVA sector, we keep trade flows and tariff at the HS6 level, pool them within each TiVA sector, and estimate the average tariff elasticity by macro TiVA sector. The coefficient attached to

⁵⁵See Appendix section B for detailed discussion on the exclusion restriction assumption of our 2SLS approach.

⁵⁶We aggregate by simple average in order to reduce endogeneity concerns. Indeed, the use of a weighted average would raise the concern of endogenous weight.

tariff is therefore the average tariff elasticity across HS6 products within a same TiVA sector, but so doing we constrain other parameters (e.g. on distance) to be equal for all products in a given TiVA sector.⁵⁷ Results from this sector aggregation are provided in table A5.⁵⁸ Pure service oriented sectors (such as Construction, Wholesales, hotel and restaurants, etc.) of the TiVA classification have indeed been excluded.

3.5.4. The role of RTA, selection and time-varying trade costs

So far we based our evidence on equation 1, which does not control for the presence of RTA among trade partners. In table 2 we showed that up to one quarter of bilateral tariffs were different from the MFN. This difference is an important source of variation of our independent variable. Consequently, any preferential market access is then captured by applied tariffs and our tariff elasticity β_0 may simply reflect the impact of RTAs. Moreover, the presence of a RTA may go beyond a simple market access effect. RTAs are signal of good political and business relationships among RTA's partners, possibly consolidated in mutual recognition of standards and certification procedures for instance. This may affect bilateral trade and then imply an omitted variable problem in equation 1. To address these potential concerns, in figure A9 we compare the baseline distribution of ε parameters (continuous line) with the empirical distribution of trade elasticities ε after controlling for the presence of RTA (dashed line) in equation 1. The two distributions are very similar suggesting that we do not introduce a systematic bias by omitting the RTA variable in our baseline equation.

Another robustness test aims at keeping only exporting countries having enough variation in the tariffs faced at destination. In figure A10 we show the empirical distribution of trade elasticities obtained using a sub-sample of exporting countries having more than five trade partners (for a given product). By the same token, keeping the sub-sample of more productive exporters (those exporting toward more than five-destinations), we reduce the selection bias in the tariff elasticity estimation by relying on a more homogeneous set of exporters. Figure

⁵⁷Since the specification is country pair-HS6-year specific, we include both exporter-HS6-year and importer-HS6-year fixed effects to fully capture the multilateral resistance term.

⁵⁸A similar empirical strategy has been used to estimate trade elasticity at the level of GTAP sector. Results are reported in table A6.

A10 shows the empirical distribution of trade elasticities ϵ : our main results are robust.

Tariff elasticity estimations may be also affected by the omission of *unobserved* time varying trade costs (such as changes over time in the cost of shipping goods across countries). To partially control for the omission of this type of variables, we include in the baseline estimation 1 country pair specific time trends. Results are reported in figure A11 and show that the inclusion of country-pair trend reduces a bit the average trade elasticity. However, with such an inclusion of country-pair trend the tariff elasticity is imprecisely estimated (not-significant) for 3495 HS6 products. In figure A11, dotted line, we also report the distribution of trade elasticity obtained by including country-pair fixed effects (not pair specific trend) in equation 1.

4. Comparison with previous estimations of trade elasticities

As discussed in the introduction, this is not the first paper in providing trade elasticity (although we are the first in relying on a systematic coverage of exporter and importer at such detailed product aggregation). So in this section we compare our trade elasticity estimations with those provided by three previous papers: (i) Caliendo & Parro (2015),⁵⁹ (ii) Ossa (2015)⁶⁰ and (iii) Broda & Weinstein (2006)⁶¹. To do so we had to aggregate our trade elasticities (by averaging) at the HS 3-digit level to compare with Broda & Weinstein (2006), at SITC rev. 3 sector level to compare with Ossa (2015), and at ISIC 2-digit level to compare with Caliendo & Parro (2015).

In table 9 we report the correlation indexes between our elasticity estimations and those in the three benchmark papers considered here. As expected, our elasticities are highly correlated with those in Caliendo & Parro (2015) as we adopt a similar methodology to recover tariff elasticities.⁶² In contrast, our elasticities are weakly correlated with those in

⁵⁹See table 1 in Caliendo & Parro (2015)

⁶⁰Available here: <https://docs.google.com/viewer?a=v&pid=sites&srcid=ZGVmYXVsdGRvbWFpbnxwcm9mb3NzYXV6aHxneDpiYTU3NmMxZTVlMmE5MGQ>

⁶¹Available here: <http://www.columbia.edu/~dew35/TradeElasticities/TradeElasticities.html>

⁶²While we use a gravity approach and Caliendo & Parro (2015) adopt a odds ratio triplets approach, the two approaches base on the trade policy shock to identify the elasticity of substitution σ .

Broda & Weinstein (2006) and Ossa (2015) that however follow a very different approach.⁶³ Since with Broda & Weinstein (2006) we share the use of the HS product classification, in figure 5 we show the correlation between our elasticity estimations and those obtained by Broda & Weinstein (2006) using data for 71 importing countries over the period 1994-2003. The values reported in figure 5 are conditioned on HS 1-digit heading to control for discrepancies raising from peculiar family of products.⁶⁴ It emerges a positive correlation between our elasticity estimations and those in Broda & Weinstein (2006).

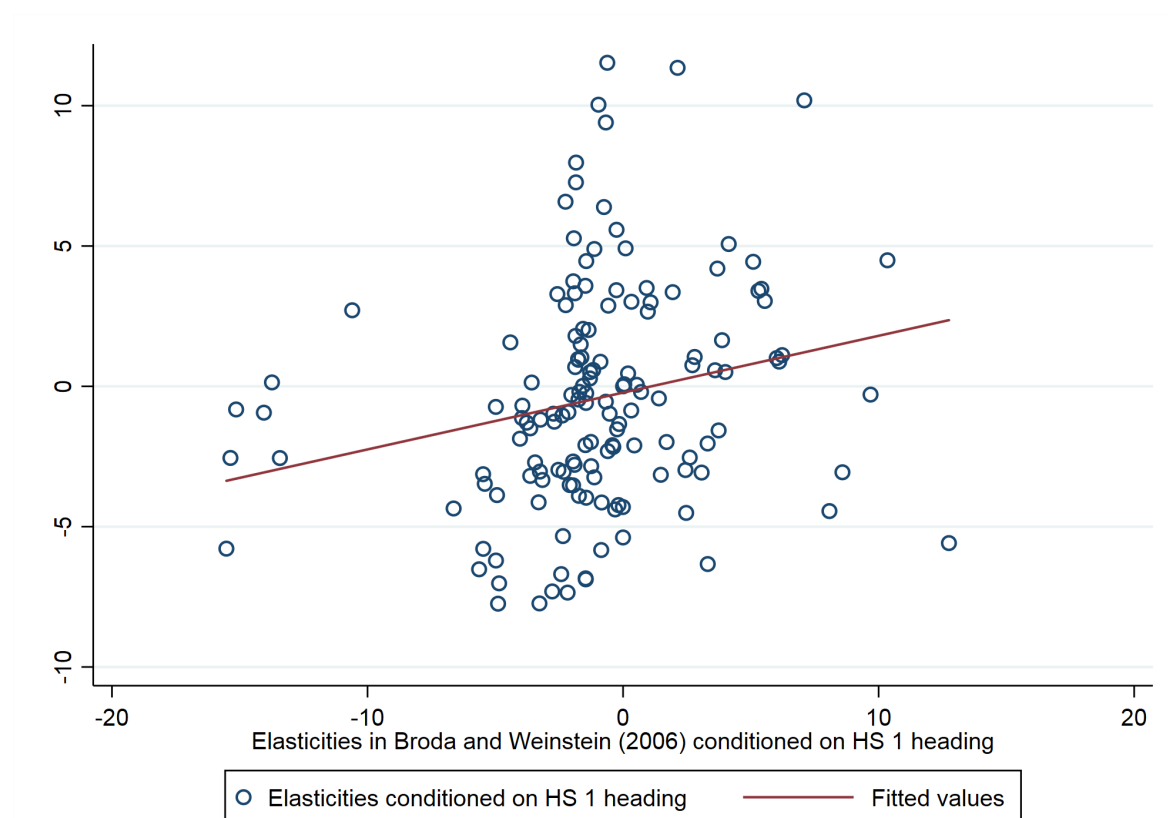
Table 9 – Correlation index and Spearman rank correlation index between tariff elasticities estimated here and those in: (i) Caliendo & Parro (2015), (ii) Ossa (2015) and (iii) Broda & Weinstein (2006)

| Reference: | Sector Classification | Correlation | Rank Correlation | obs. |
|--------------------------|-----------------------|-------------|------------------|------|
| Broda & Weinstein (2006) | HS 3 digit | 0.13 | 0.18 | 167 |
| Ossa (2015) | SITC 3 digit | -0.05 | -0.18 | 241 |
| Caliendo & Parro (2015) | ISIC 2 digit | 0.81 | 0.19 | 15 |

⁶³Notice that when computed at SITC rev. 3 level, elasticity values in Broda & Weinstein (2006) and Ossa (2015) are almost uncorrelated (correlation index equal to 0.004)

⁶⁴Namely, we regress elasticity estimations on HS 1-digit fixed effects and plot the residuals in figure 5.

Figure 5 – Empirical distribution of tariff elasticity β_0 . Comparison with Broda & Weinstein (2006)



Source: Authors' calculations. Note: the value of elasticities reported in the figure are conditioned on HS 1-digit heading fixed effects. To the sake of readability, outliers (i.e. elasticities above the 97th percentile and below the 3th) are not reported.

5. Gains from trade with heterogeneous elasticities

The strong heterogeneity in the trade elasticity ε showed so far raises the question of whether using sector specific trade elasticity changes the evaluation of the gains from trade as obtained for example by Arkolakis et al. (2012) - ACR methodology. Whether sectoral heterogeneity of trade elasticity delivers systematically higher (or lower) gains from trade depends on the combination of the trade elasticity, the consumption shares of sectors and the penetration of imports. In general, everything else being equal in terms of import penetration, having high consumption share in low elastic sectors (i.e. where trade elasticity is smaller than the average) magnifies the gains from trade. And for a given consumption share, a high penetration of imports in low elastic sectors maximizes the gains from trade. In this section we tentatively sort out this question and evaluate the gains from trade obtained using trade elasticities *heterogeneous* across sectors, and compare with those obtained using *homogeneous* (sector invariant) elasticity.

To proceed, we follow closely Arkolakis et al. (2012) and compute the gains from trade as the negative of moving to autarky, with heterogeneous trade elasticities across sectors. The change in real income is related to the total expenditure devoted to domestic production (domestic market share) and the trade elasticity. We use TiVA (OECD) data to compute both the share of total expenditure of country j devoted to domestic production (i.e. λ_{jj} in ACR), and the consumption share of country j in sector s (i.e. η_{js} , the upper-tier in the consumer utility in ACR). Then we compare the ex-ante evaluation of welfare gain obtained using heterogeneous trade elasticity with the case of homogeneous elasticity across sectors (average ε across sectors). Everything else being equal, the magnitude of the gains is indeed increasing in the dispersion of sectoral elasticities (Ossa 2015). However, the extent of the bias in the estimation of welfare gains also depends on the country-sector share of domestic expenditure (the inverse of the import penetration ratio in the sector) and consumption shares (Giri et al. 2018).

In figure 6 we correlate the extent of the bias in welfare gains evaluation (vertical axis),

calculated as the difference in sectoral welfare change using respectively heterogeneous trade elasticity (\widehat{W}^{Hetero}) and homogeneous elasticity (\widehat{W}^{Homog}) - based on the average trade elasticity (ϵ) in our dataset, with the difference between the elasticity estimated for the sector at stake and the average (homogeneous) trade elasticity (horizontal axis). We do so for the United States and China (as examples of big developed and developing countries). It clearly emerges that in sectors where the "actual" trade elasticity is below average, using homogeneous trade elasticity implies a downward bias in the estimation of welfare gains from trade – and conversely in sectors where trade elasticity is above average.

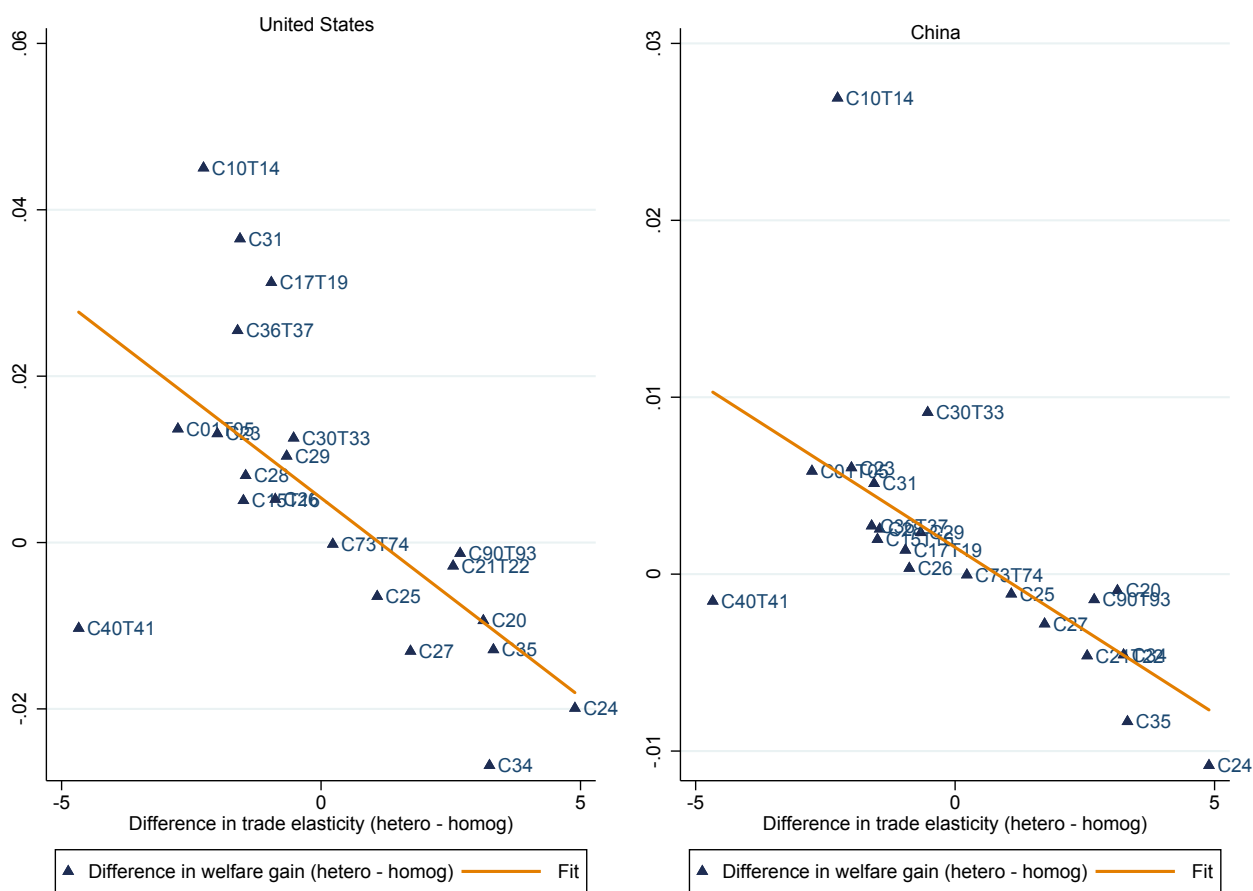
In figure 7 we report the extent of the bias in welfare gains evaluation calculated as discussed above (vertical axis), and rank countries by (the logarithm of) per capita income in 2010 (horizontal axis). Figure 7 shows that the under-estimation of welfare gains using average homogeneous trade elasticity is decreasing in per-capita income: using homogeneous rather than "actual" sector specific trade elasticity introduces a downward bias in the welfare gain estimation in particular for poor and developing countries. Also, the dispersion of the bias in welfare evaluation are larger for high income countries. All in all, the dispersion of observations in figure 7 suggests that the bias is far from being systematic.

Finally, in a robustness check reported in the appendix section, we adopt homogeneous trade elasticity from three benchmark papers: (i) Feenstra et al. (2014) finding an elasticity governing the substitution between varieties of foreign goods equal to 4.4; (ii) Bas et al. (2017) who find average elasticity around 5; and Romalis (2007) who finds an elasticity equal to 8.5.⁶⁵ See Appendix tables A7 and A8. The comparison of column 1 with the subsequent ones illustrates the expected large impact of the set of trade elasticity estimates used, on the results of the ex-ante evaluation of welfare changes.⁶⁶

⁶⁵Depending on the specification, Romalis (2007) finds elasticities of substitution spanning from 6 to 11 - see tables 3A and 3B in Romalis (2007). Here we take the average of these elasticities as a benchmark.

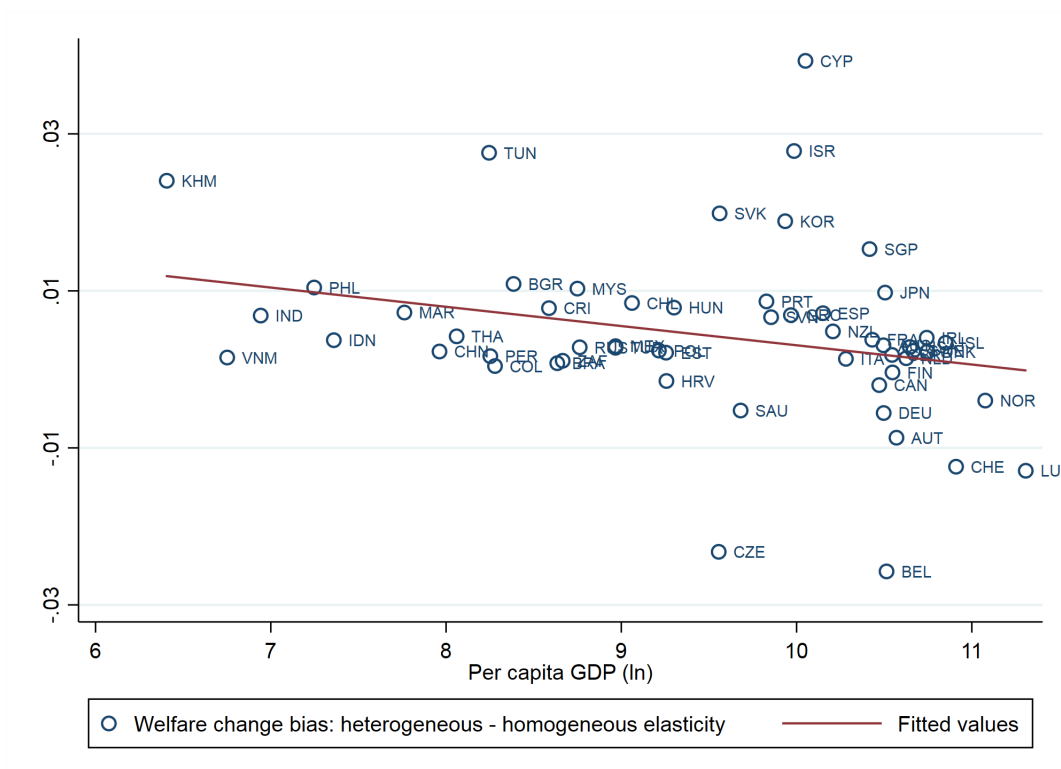
⁶⁶Tariff elasticity cannot be estimated for pure service sectors where tariffs are absent. So the welfare change evaluations reported here consider only TiVA manufacturing sectors (see table A5 for the list of elasticity parameters by TiVA sector). We keep all TiVA sectors covering at least one HS6 tariff elasticity. That's why in table A5 we also report some service oriented sectors. These results are therefore not fully comparable with a pure general equilibrium exercise as the one reported in Arkolakis et al. (2012) that considers also service sectors in the calculation of the import penetration. In Arkolakis et al. (2012) the absence of elasticity parameter for service sectors is not an issue as they consider a homogeneous elasticity parameter for all sectors (manufacturing and service).

Figure 6 – Correlation between bias in sectoral welfare change evaluation (heterogeneous vs homogeneous trade elasticity) and difference to the mean trade elasticity, for US and China in 2010.



Source: Authors' calculations. The vertical axis reports the difference in the welfare change computed using heterogeneous elasticity (\widehat{W}^{Hetero}) and homogeneous elasticity (\widehat{W}^{Homog}) based on the average ϵ across products in our dataset.

Figure 7 – Correlation between bias in welfare change evaluation (heterogeneous vs homogeneous trade elasticity) and per capita GDP in 2010.



Source: Authors' calculations. The vertical axis reports the difference in the welfare change computed using heterogeneous elasticity (\widehat{W}^{Hetero}) and homogeneous elasticity (\widehat{W}^{Homog}) based on the average ϵ across products in our dataset.

6. Conclusion

The main contribution of this paper is to offer an estimate of trade elasticity (through the estimation of tariff elasticities in a gravity framework) for the recent period and at the product level, by exploiting the variation over the period 2001-2016 in bilateral applied tariffs for each product category for the universe of available country pairs. We combine two databases covering the universe of exporters, importers and products at the finest level of disaggregation (6-digit of the Harmonized system). Although we obtain average trade elasticity in line with the one used in the literature, we also shed light on the large variation around this value generally used to calibrate empirical exercises. We illustrate the impact of such heterogeneity of elasticities on the estimation of welfare gain from trade with a simple exercise in line with Arkolakis et al. (2012). For the sake of further utilization by the profession, this unique set of elasticities is made available on a dedicated web-page.

Bibliography

- Amiti, M., Redding, S. J. & Weinstein, D. E. (2019), 'The impact of the 2018 tariffs on prices and welfare', *Journal of Economic Perspectives* **33**(4), 187–210.
- Anderson, J. E. & Yotov, Y. V. (2016), 'Terms of trade and global efficiency effects of free trade agreements 1990-2002', *Journal of International Economics* **99**(C), 279–298.
- Anderson, J., Larch, M. & Yotov, Y. (2018), 'Estimating general equilibrium trade policy effects: GE PPML', *The World Economy* **41**(10), 2750 – 2782.
- Arkolakis, C., Costinot, A. & Rodriguez-Clare, A. (2012), 'New trade models, same old gains?', *American Economic Review* **102**(1), 94 – 130.
- Armington, P. S. (1969), 'A theory of demand for products distinguished by place of production', *Staff Papers* **16**(1), 159–178.
- Atkeson, A. & Burstein, A. (2008), 'Pricing-to-market, trade costs, and international relative prices', *American Economic Review*, **98**(5), 1998–2031.
- Bas, M., Mayer, T. & Thoenig, M. (2017), 'From micro to macro: Demand, supply, and heterogeneity in the trade elasticity', *Journal of International Economics* **108**(C), 1–19.
- Bertoletti, P., Etro, F. & Simonovska, I. (2018), 'International trade with indirect additivity', *American Economic Journal: Microeconomics* **10**(2), 1–57.
- Bouët, A., Decreux, Y., Fontagné, L., Jean, S. & Laborde, D. (2008), 'Assessing applied protection across the world', *Review of International Economics* **16**(5), 850–863.
- Broda, C., Greenfield, J. & Weinstein, D. (2006), From groundnuts to globalization: A structural estimate of trade and growth, Technical report, National Bureau of Economic Research.
- Broda, C. & Weinstein, D. (2006), 'Globalization and the gains from variety', *Quarterly Journal of Economics* **121**(2).
- Brooks, W. J. & Pujolas, P. S. (forthcoming), 'Gains from trade with variable trade elasticities', *International Economic Review* **0**(0).
URL: <https://onlinelibrary.wiley.com/doi/abs/10.1111/iere.12399>
- Caliendo, L. & Parro, F. (2015), 'Estimates of the trade and welfare effects of NAFTA', *The Review of Economic Studies* **82**(1), 1–44.
- Chaney, T. (2008), 'Distorted gravity: the intensive and extensive margins of international trade', *American Economic Review* **98**(4), 1707–1721.
- Costinot, A. & Rodriguez-Clare, A. (2014), Trade theory with numbers: Quantifying the consequences of globalization, in 'Handbook of international economics', Vol. 4, Elsevier, pp. 197–261.
- Costinot, A. & Rodriguez-Clare, A. (2018), 'The US gains from trade: Valuation using the demand for foreign factor services', *Journal of Economic Perspectives* **32**(2), 3–24.

URL: <http://www.aeaweb.org/articles?id=10.1257/jep.32.2.3>

- Eaton, J. & Kortum, S. (2002), 'Technology, geography, and trade', *Econometrica* **70**(5), 1741–1779.
- Fajgelbaum, P. D., Goldberg, P. K., Kennedy, P. J. & Khandelwal, A. K. (2020), 'The return to protectionism', *The Quarterly Journal of Economics* **135**(1), 1–55.
- Fally, T. (2015), 'Structural gravity and fixed effects', *Journal of International Economics* **97**(1), 76–85.
- Feenstra, R. C. (1994), 'New product varieties and the measurement of international prices', *The American Economic Review* pp. 157–177.
- Feenstra, R. C., Luck, P. A., Obstfeld, M. & Russ, K. N. (2014), 'In search of the armington elasticity', *NBER Working Paper No. 20063*.
- Fontagné, L., Martin, P. & Orefice, G. (2018), 'The international elasticity puzzle is worse than you think', *Journal of International Economics*.
- Fontagné, L. & Orefice, G. (2018), 'Let's try next door: Technical barriers to trade and multi-destination firms', *European Economic Review* **101**, 643–663.
- Freund, C. & Ornelas, E. (2010), 'Regional trade agreements', *Annual Review of Economics* **2**(1), 139–166.
- Gaulier, G. & Zignago, S. (2010), Baci: International trade database at the product-level. the 1994–2007 version, Working Papers 2010–23, CEPII.
- URL:** <http://www.cepii.fr/CEPII/fr/publications/wp/abstract.asp?NoDoc=2726>
- Gawande, K. & Bandyopadhyay, U. (2000), 'Is protection for sale? evidence on the grossman–helpman theory of endogenous protection', *Review of Economics and Statistics* **82**(1), 139–152.
- Giri, R., Yi, K.-M. & Yilmazkuday, H. (2018), Gains from trade: Does sectoral heterogeneity matter?, Technical report, Globalization and Monetary Policy Institute Working Paper No. 341.
- Goldberg, P. K. & Pavcnik, N. (2016), The effects of trade policy, in 'Handbook of commercial policy', Vol. 1, Elsevier, pp. 161–206.
- Guimbard, H., Jean, S., Mimouni, M. & Pichot, X. (2012), 'MAcMap-HS6 2007, an Exhaustive and Consistent Measure of Applied Protection in 2007', *International Economics* (130), 99–122.
- Head, K. & Mayer, T. (2002), Illusory border effects: Distance mismeasurement inflates estimates of home bias in trade, Technical Report 2002-01, CEPII Working paper.
- Head, K. & Mayer, T. (2014), Gravity equations: Workhorse, toolkit, and cookbook, Vol. 4, Handbook of International Economics, Gita Gopinath, Elhanan Helpman and Kenneth Rogoff editors, chapter 4.
- Head, K., Mayer, T. & Ries, J. (2010), 'The erosion of colonial trade linkages after inde-

- pendence', *Journal of international Economics* **81**(1), 1–14.
- Head, K. & Ries, J. (2001), 'Increasing returns versus national product differentiation as an explanation for the pattern of us-canada trade', *American Economic Review* **91**(4), 858–876.
- Hertel, T., Hummels, D., Ivanic, M. & Keeney, R. (2007), 'How confident can we be of cge-based assessments of free trade agreements?', *Economic Modelling* **24**(4), 611–635.
- Hillberry, R. H., Anderson, M. A., Balistreri, E. J. & Fox, A. K. (2005), 'Taste parameters as model residuals: assessing the fit of an armington trade model', *Review of International Economics* **13**(5), 973–984.
- Hummels, D. & Skiba, A. (2004), 'Shipping the good apples out? an empirical confirmation of the alchian-allen conjecture', *Journal of Political Economy* **112**(6), 1384–1402.
- Imbruno, M. (2016), 'China and wto liberalization: Imports, tariffs and non-tariff barriers', *China Economic Review* **38**, 222–237.
- Imbs, J. & Mejean, I. (2015), 'Elasticity Optimism', *American Economic Journal: Macroeconomics* **3**(7), 43–83.
- Kee, H. L., Nicita, A. & Olarreaga, M. (2008a), 'Estimating trade restrictiveness indices', *The Economic Journal* **119**(534), 172–199.
- Kee, H. L., Nicita, A. & Olarreaga, M. (2008b), 'Import demand elasticities and trade distortions', *The Review of Economics and Statistics* **90**(4), 666–682.
- Markusen, J. R. (2013), 'Putting per-capita income back into trade theory', *Journal of International Economics* **90**(2), 255–265.
- Martin, P., Mayer, T. & Thoenig, M. (2008), 'Make trade not war?', *The Review of Economic Studies* **75**(3), 865–900.
- Orefice, G. (2017), 'Non-tariff measures, specific trade concerns and tariff reduction', *The World Economy* **40**(9), 1807–1835.
- Ossa, R. (2014), 'Trade wars and trade talks with data', *American Economic Review* **104**(12), 4104–46.
- Ossa, R. (2015), 'Why trade matters after all', *Journal of International Economics* **97**(2), 266–277.
- Romalis, J. (2007), 'Nafta's and cusfta's impact on international trade', *The Review of Economics and Statistics* **89**(3), 416–435.
- Santos-Silva, J. M. C. & Tenreyro, S. (2006), 'The Log of Gravity', *The Review of Economics and Statistics* **88**(4), 641–658.
- Shapiro, J. S. (2016), 'Trade costs, co2, and the environment', *American Economic Journal: Economic Policy* **8**(4), 220–54.
URL: <http://www.aeaweb.org/articles?id=10.1257/pol.20150168>
- Simonovska, I. & Waugh, M. E. (2014a), 'The elasticity of trade: Estimates and evidence',

Journal of International Economics **92**(1), 34 – 50.

Soderbery, A. (2018), 'Trade elasticities, heterogeneity, and optimal tariffs', *Journal of International Economics* **114**, 44–62.

Appendix

A. Appendix tables and figures

Table A1 – List of importing countries included in the estimation of equation 1

| | | | |
|------------------------|--------------------|-----------------------|----------------------------------|
| Albania | Dominica | Latvia | Saint Lucia |
| Algeria | Dominican Republic | Lebanon | Saint Vincent and the Grenadines |
| Antigua and Barbuda | Ecuador | Libya | Saudi Arabia |
| Argentina | Egypt | Lithuania | Senegal |
| Armenia | El Salvador | Macedonia | Seychelles |
| Australia | Equatorial Guinea | Madagascar | Singapore |
| Austria | Eritrea | Malawi | Slovakia |
| Azerbaijan | Estonia | Malaysia | Slovenia |
| Bahamas | Ethiopia | Maldives | Solomon Islands |
| Bahrain | Finland | Mali | South Africa |
| Bangladesh | France | Malta | South Korea |
| Barbados | Gabon | Mauritania | Spain |
| Belarus | Georgia | Mauritius | Sri Lanka |
| Belize | Germany | Mexico | Sudan |
| Benin | Ghana | Moldova | Suriname |
| Bermuda | Greece | Morocco | Sweden |
| Bhutan | Grenada | Mozambique | Switzerland |
| Bolivia | Guatemala | Myanmar | Syria |
| Bosnia and Herzegovina | Guinea Bissau | Nepal | Tajikistan |
| Brazil | Guyana | Netherlands | Tanzania |
| Brunei Darussalam | Honduras | New Zealand | Thailand |
| Burkina Faso | Hong Kong | Nicaragua | Togo |
| Cambodia | Hungary | Niger | Trinidad and Tobago |
| Cameroon | Iceland | Nigeria | Tunisia |
| Canada | India | Norway | Turkey |
| Central African Rep. | Indonesia | Oman | Uganda |
| Chad | Iran | Pakistan | Ukraine |
| Chile | Ireland | Panama | United Arab Emirates |
| China | Israel | Papua New Guinea | United Kingdom |
| Colombia | Italy | Paraguay | United States of America |
| Congo | Jamaica | Peru | Uruguay |
| Costa Rica | Japan | Philippines | Uzbekistan |
| Côte d'Ivoire | Jordan | Poland | Vanuatu |
| Croatia | Kazakhstan | Portugal | Venezuela |
| Cuba | Kenya | Qatar | Vietnam |
| Cyprus | Kuwait | Russia | Yemen |
| Czech Republic | Kyrgyzstan | Rwanda | Zambia |
| Denmark | Lao | Saint Kitts and Nevis | Zimbabwe |

Table A2 – Descriptive statistics. Average tariff by HS section and year.

| Section | Description | 2001 | 2004 | 2007 | 2010 | 2013 | 2016 |
|---------|--|------|------|------|------|------|------|
| I | Live Animals and Animal Products | 17.4 | 17.6 | 16.4 | 15.5 | 14.8 | 14.2 |
| II | Vegetable Products | 15.3 | 15.2 | 13.5 | 13.0 | 12.5 | 11.7 |
| III | Animal or vegetable fats and oils | 13.6 | 13.6 | 12.0 | 11.0 | 10.6 | 10.4 |
| IV | Prepared foodstuffs, beverages and tobacco | 21.4 | 21.6 | 19.8 | 18.9 | 17.5 | 16.9 |
| V | Mineral products | 5.5 | 5.3 | 4.7 | 4.4 | 4.2 | 3.9 |
| VI | Products of chemical industries | 6.3 | 6.1 | 5.0 | 4.7 | 4.5 | 4.3 |
| VII | Plastic and articles thereof | 9.3 | 9.0 | 7.6 | 7.2 | 7.0 | 6.7 |
| VIII | Raw hides and skins, leather and article thereof | 11.2 | 11.0 | 9.7 | 9.5 | 9.1 | 8.6 |
| IX | Wood/Cork and articles of Wood/Cork; | 11.0 | 10.8 | 9.2 | 8.9 | 8.5 | 8.0 |
| X | Pulp of wood or other cellulose materials | 8.3 | 8.2 | 7.2 | 7.0 | 6.6 | 6.2 |
| XI | Textile and textile articles | 14.6 | 13.1 | 11.8 | 11.4 | 10.9 | 10.5 |
| XII | Footwear, Headgear, Umbrellas and prepared feathers | 16.6 | 16.2 | 14.4 | 14.0 | 13.3 | 12.6 |
| XIII | Articles of stone, plaster, ceramic and glass | 11.8 | 11.5 | 10.3 | 9.9 | 9.6 | 9.2 |
| XIV | Natural cultured pearls and precious stones and metals | 11.4 | 11.0 | 9.5 | 9.5 | 9.0 | 8.5 |
| XV | Base metals and articles of base metals | 8.3 | 8.1 | 7.1 | 6.8 | 6.5 | 6.2 |
| XVI | Machinery and mechanical appliances and electrical machinery | 6.9 | 6.8 | 5.8 | 5.4 | 5.1 | 4.9 |
| XVII | Vehicles, Aircraft and transport equipment | 9.7 | 9.4 | 8.1 | 7.6 | 7.1 | 6.8 |
| XVIII | Optical, photographic, precision and medical instruments | 8.6 | 8.5 | 7.3 | 6.9 | 6.6 | 6.3 |
| XIX | Arms and ammunitions | 18.2 | 18.2 | 16.5 | 15.9 | 15.1 | 13.5 |
| XX | Miscellaneous | 14.2 | 13.9 | 12.3 | 12.1 | 11.6 | 11.3 |
| XXI | Works of art | 10.8 | 10.5 | 9.4 | 9.4 | 9.0 | 8.5 |

Note: This table reports the simple average tariffs by HS section and year.

Source: MAcMap-HS6, authors' calculation.

Table A3 – Descriptive statistics. Standard deviation of tariffs by HS section and year.

| Section | Description | 2001 | 2004 | 2007 | 2010 | 2013 | 2016 |
|---------|--|------|------|------|------|------|------|
| I | Live Animals and Animal Products | 28.9 | 31.4 | 31.8 | 28.0 | 27.4 | 26.2 |
| II | Vegetable Products | 29.2 | 30.3 | 26.2 | 24.6 | 23.3 | 23.1 |
| III | Animal or vegetable fats and oils | 17.8 | 19.2 | 17.5 | 16.1 | 16.1 | 16.1 |
| IV | Prepared foodstuffs, beverages and tobacco | 41.4 | 46.9 | 47.8 | 45.6 | 39.9 | 38.6 |
| V | Mineral products | 7.4 | 7.5 | 6.7 | 6.7 | 11.3 | 6.4 |
| VI | Products of chemical industries | 9.2 | 10.0 | 8.6 | 8.5 | 8.2 | 7.4 |
| VII | Plastic and articles thereof | 10.5 | 11.1 | 9.6 | 9.5 | 9.6 | 8.9 |
| VIII | Raw hides and skins, leather and article thereof | 13.5 | 14.0 | 13.0 | 13.1 | 12.9 | 11.3 |
| IX | Wood/Cork and articles of Wood/Cork; | 16.4 | 16.7 | 10.8 | 10.7 | 10.4 | 9.8 |
| X | Pulp of wood or other cellulose materials | 9.6 | 10.7 | 9.3 | 9.3 | 8.8 | 8.5 |
| XI | Textile and textile articles | 34.6 | 14.3 | 13.9 | 13.3 | 13.3 | 13.1 |
| XII | Footwear, Headgear, Umbrellas and prepared feathers | 15.6 | 16.8 | 14.7 | 14.4 | 13.9 | 13.3 |
| XIII | Articles of stone, plaster, ceramic and glass | 11.9 | 12.9 | 11.3 | 11.2 | 11.0 | 10.7 |
| XIV | Natural cultured pearls and precious stones and metals | 13.8 | 13.7 | 12.2 | 12.4 | 12.0 | 11.6 |
| XV | Base metals and articles of base metals | 9.2 | 10.4 | 8.8 | 8.9 | 8.6 | 8.3 |
| XVI | Machinery and mechanical appliances and electrical machinery | 8.5 | 10.2 | 8.1 | 8.1 | 7.8 | 7.6 |
| XVII | Vehicles, Aircraft and transport equipment | 14.6 | 15.1 | 12.5 | 11.9 | 11.5 | 10.5 |
| XVIII | Optical, photographic, precision and medical instruments | 10.2 | 11.7 | 9.5 | 9.5 | 9.2 | 9.0 |
| XIX | Arms and ammunitions | 26.1 | 27.0 | 25.4 | 24.9 | 21.2 | 15.1 |
| XX | Miscellaneous | 12.8 | 13.7 | 12.2 | 12.1 | 11.9 | 11.6 |
| XXI | Works of art | 12.6 | 12.5 | 11.3 | 11.4 | 11.2 | 11.0 |

Note: This table reports the standard deviation of tariffs by HS section and year.

Source: MAcMap-HS6, authors' calculation.

Table A4 – Ratio of trade elasticity obtained by: (i) HS 6-digit vs 4-digit; (ii) HS 6-digit vs 2-digit.

| Chapter | $\epsilon^{HS6}/\epsilon^{HS4}$ | $\epsilon^{HS6}/\epsilon^{HS2}$ |
|---------|---------------------------------|---------------------------------|
| I | 1.82 | 1.55 |
| II | 0.89 | 1.45 |
| III | 1.14 | 2.23 |
| IV | 1.18 | 1.13 |
| V | 0.94 | 1.63 |
| VI | 0.94 | 1.07 |
| VII | 0.87 | 0.78 |
| VIII | 0.89 | 0.93 |
| IX | 0.70 | 0.97 |
| X | 0.84 | 0.95 |
| XI | 0.79 | 0.88 |
| XII | 0.74 | 0.74 |
| XIII | 0.90 | 1.00 |
| XIV | 0.95 | 1.28 |
| XV | 0.80 | 1.36 |
| XVI | 0.72 | 1.33 |
| XVII | 0.81 | 0.65 |
| XVIII | - | - |
| XIX | 0.77 | 1.42 |
| XX | 0.99 | 1.16 |
| XXI | - | - |

Note descriptive statistics reported in this table are calculated excluding positive trade elasticities. Chapters XIII and XXI are not reported because positive trade elasticity obtained at HS 2-digit level.

Table A5 – Trade elasticity ε by TiVA 2016 sectors used to compute gain from trade in section 3.

| TiVA Industry code | Heading | Elasticity ε |
|--------------------|--|--------------------------|
| C01T05 | Agriculture, hunting, forestry and fishing | -2.91 |
| C10T14 | Mining and quarrying | -3.41 |
| C15T16 | Food products, beverages and tobacco | -4.17 |
| C17T19 | Textiles, textile products, leather and footwear | -4.71 |
| C20 | Wood and products of wood and cork | -8.80 |
| C21T22 | Pulp, paper, paper products, printing and publishing | -8.21 |
| C23 | Coke, refined petroleum products and nuclear fuel | -3.67 |
| C24 | Chemicals and chemical products | -10.56 |
| C25 | Rubber and plastics products | -6.75 |
| C26 | Other non-metallic mineral products | -4.79 |
| C27 | Basic metals | -7.39 |
| C28 | Fabricated metal products | -4.22 |
| C29 | Machinery and equipment, nec | -5.01 |
| C30T33X | Computer, electronic and optical equipment | -5.14 |
| C31 | Electrical machinery and apparatus, nec | -4.11 |
| C34 | Motor vehicles, trailers and semi-trailers | -8.92 |
| C35 | Other transport equipment | -8.99 |
| C36T37 | Manufacturing nec; recycling | -4.06 |
| C40T41 | Electricity, gas and water supply | NS |
| C73T74 | R&D and other business activities | -5.90 |
| C90T93 | Other community, social and personal services | -8.35 |

Note we consider TiVA sectors that include at least one HS6 products with non-missing tariff.

Table A6 – Trade elasticity by GTAP sectors.

| GTAP sector | Trade elasticity ε |
|--|--------------------------------|
| Animal products n.e.c. | -4.79 |
| Beverages and tobacco products | -3.12 |
| Bovine cattle, sheep and goats, horses | -6.39 |
| Bovine meat prods | -3.30 |
| Cereal grains n.e.c. | NS |
| Chemical, rubber, plastic products | -9.90 |
| Coal | NS |
| Crops n.e.c. | -1.00 |
| Dairy products | -4.80 |
| Electricity | NS |
| Electronic equipment | -5.57 |
| Ferrous metals | -3.45 |
| Fishing | -6.99 |
| Food products n.e.c. | -4.67 |
| Forestry | -2.42 |
| Gas | NS |
| Gas manufacture, distribution | NS |
| Leather products | -6.01 |
| Machinery and equipment n.e.c. | -5.43 |
| Manufactures n.e.c. | -3.32 |
| Meat products n.e.c. | -5.42 |
| Metal products | -4.50 |
| Metals n.e.c. | -14.74 |
| Mineral products n.e.c. | -4.80 |
| Minerals n.e.c. | -8.27 |
| Motor vehicles and parts | -8.89 |
| Oil | -10.89 |
| Oil seeds | -2.05 |
| Paddy rice | -3.88 |
| Paper products, publishing | -8.18 |
| Petroleum, coal products | -3.64 |
| Plant | -12.26 |
| Processed rice | -6.94 |
| Sugar | -3.73 |
| Sugar cane, sugar beet | -0.67 |
| Textiles | -6.28 |
| Transport equipment n.e.c. | -8.98 |
| Vegetable oils and fats | -2.63 |
| Vegetables, fruit, nuts | -4.11 |
| Wearing apparel | -3.01 |
| Wheat | -2.61 |
| Wood products | -7.94 |
| Wool, silk | NS |

Note: we consider GTAP sectors that include at least one HS6 products with non-missing tariff.

Table A7 – Ex ante welfare evaluation: moving to autarky. Change in log real income across non-OECD countries. ACR formula with homogeneous trade elasticity.

| | Homogeneous elasticity across sectors: | | | |
|--------------------|--|--|-----------------------------------|---------------------------------|
| | Average ($1 - \sigma_s$) | <i>Feenstra</i> <i>et al (2014)</i> | <i>Bas</i> <i>et al.(2017)</i> | <i>Romalis</i> <i>(2007)</i> |
| Argentina | 0.028 | 0.042 | 0.037 | 0.022 |
| Brazil | 0.016 | 0.025 | 0.022 | 0.013 |
| Bulgaria | 0.085 | 0.127 | 0.113 | 0.068 |
| China | 0.014 | 0.022 | 0.019 | 0.011 |
| Croatia | 0.058 | 0.088 | 0.078 | 0.047 |
| Cyprus | 0.205 | 0.296 | 0.266 | 0.166 |
| India | 0.032 | 0.048 | 0.043 | 0.025 |
| Indonesia | 0.033 | 0.050 | 0.044 | 0.026 |
| Romania | 0.058 | 0.088 | 0.078 | 0.046 |
| Russian Federation | 0.035 | 0.053 | 0.047 | 0.028 |
| Saudi Arabia | 0.103 | 0.154 | 0.136 | 0.083 |
| South Africa | 0.050 | 0.075 | 0.067 | 0.040 |

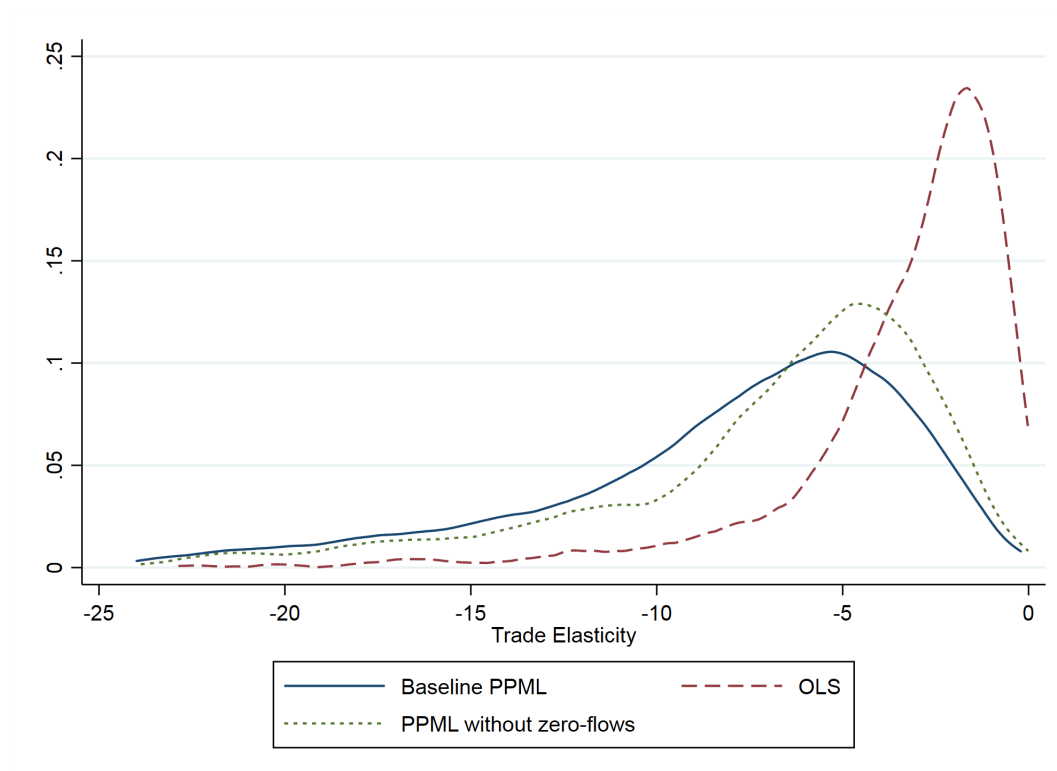
Note: In computing the cost of autarky we follow ACR(2010) sections 3.3 and 5.1. To compute change in welfare following elasticity in Feenstra et al. (2014), Bas et al. (2017) and Romalis (2007) we used $(1 - \sigma)$ respectively equal to 4.4, 5 and 8.5. *Source:* Authors' calculation.

Table A8 – Ex ante welfare evaluation: moving to autarky. Change in log real income across OECD countries. ACR formula with homogeneous trade elasticity.

| | Homogeneous elasticity across sectors: | | | |
|----------------|--|----------------------------------|-----------------------------|---------------------------|
| | Average ($1 - \sigma_s$) | <i>Feenstra et al (2014)</i> | <i>Bas et al.(2017)</i> | <i>Romalis (2007)</i> |
| Australia | 0.056 | 0.085 | 0.075 | 0.045 |
| Austria | 0.072 | 0.108 | 0.095 | 0.057 |
| Belgium | 0.060 | 0.090 | 0.080 | 0.048 |
| Canada | 0.083 | 0.124 | 0.110 | 0.066 |
| Chile | 0.069 | 0.103 | 0.092 | 0.055 |
| Czech Republic | 0.074 | 0.111 | 0.099 | 0.059 |
| Denmark | 0.062 | 0.093 | 0.082 | 0.049 |
| Estonia | 0.100 | 0.149 | 0.133 | 0.080 |
| Finland | 0.069 | 0.103 | 0.091 | 0.055 |
| France | 0.058 | 0.087 | 0.077 | 0.046 |
| Germany | 0.053 | 0.081 | 0.071 | 0.043 |
| Greece | 0.097 | 0.144 | 0.128 | 0.077 |
| Hungary | 0.115 | 0.171 | 0.152 | 0.092 |
| Iceland | 0.118 | 0.175 | 0.156 | 0.095 |
| Ireland | 0.120 | 0.178 | 0.158 | 0.096 |
| Israel | 0.095 | 0.142 | 0.126 | 0.076 |
| Italy | 0.051 | 0.077 | 0.068 | 0.040 |
| Japan | 0.028 | 0.043 | 0.038 | 0.023 |
| Luxembourg | 0.279 | 0.394 | 0.356 | 0.228 |
| Mexico | 0.068 | 0.102 | 0.090 | 0.054 |
| Netherlands | 0.059 | 0.089 | 0.079 | 0.047 |
| New Zealand | 0.052 | 0.079 | 0.070 | 0.042 |
| Norway | 0.066 | 0.099 | 0.088 | 0.052 |
| Poland | 0.066 | 0.100 | 0.088 | 0.053 |
| Portugal | 0.084 | 0.126 | 0.111 | 0.067 |
| Slovakia | 0.116 | 0.172 | 0.153 | 0.093 |
| Slovenia | 0.107 | 0.159 | 0.141 | 0.086 |
| South Korea | 0.056 | 0.084 | 0.075 | 0.045 |
| Spain | 0.067 | 0.100 | 0.089 | 0.053 |
| Sweden | 0.073 | 0.109 | 0.097 | 0.058 |
| Switzerland | 0.092 | 0.137 | 0.122 | 0.073 |
| Turkey | 0.037 | 0.056 | 0.050 | 0.030 |
| United Kingdom | 0.078 | 0.117 | 0.104 | 0.063 |
| United States | 0.036 | 0.055 | 0.048 | 0.029 |

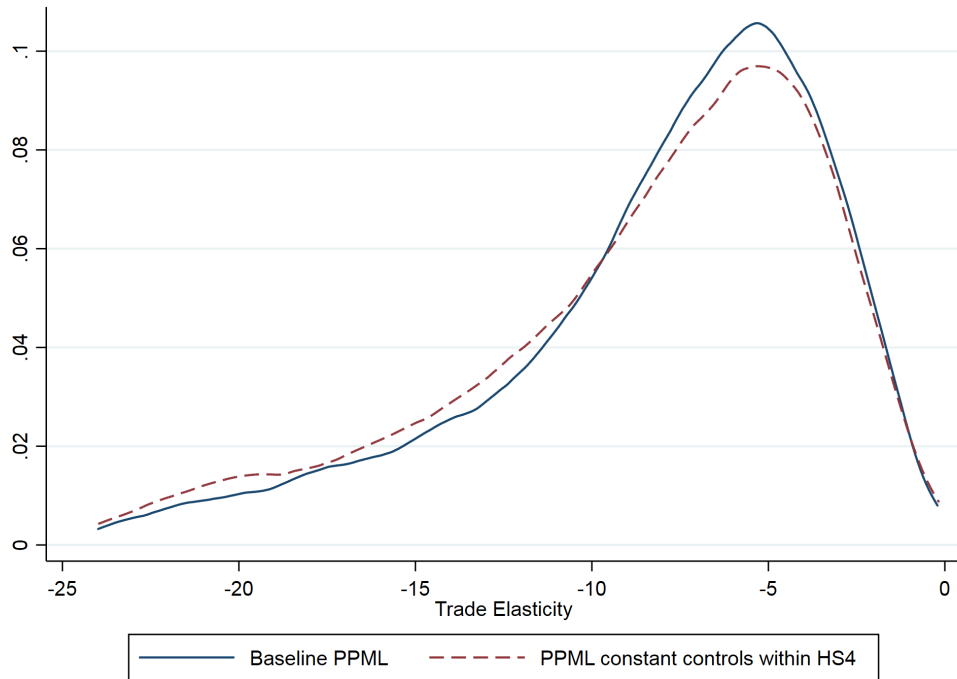
Note: In computing the cost of autarky we follow ACR(2010) sections 3.3 and 5.1. To compute change in welfare following elasticity in Feenstra et al. (2014), Bas et al. (2017) and Romalis (2007) we used $(1 - \sigma)$ respectively equal to 4.4, 5 and 8.5. *Source:* Authors' calculation.

Figure A1 – Empirical distribution of trade elasticity ε across all products. OLS vs PPML estimations



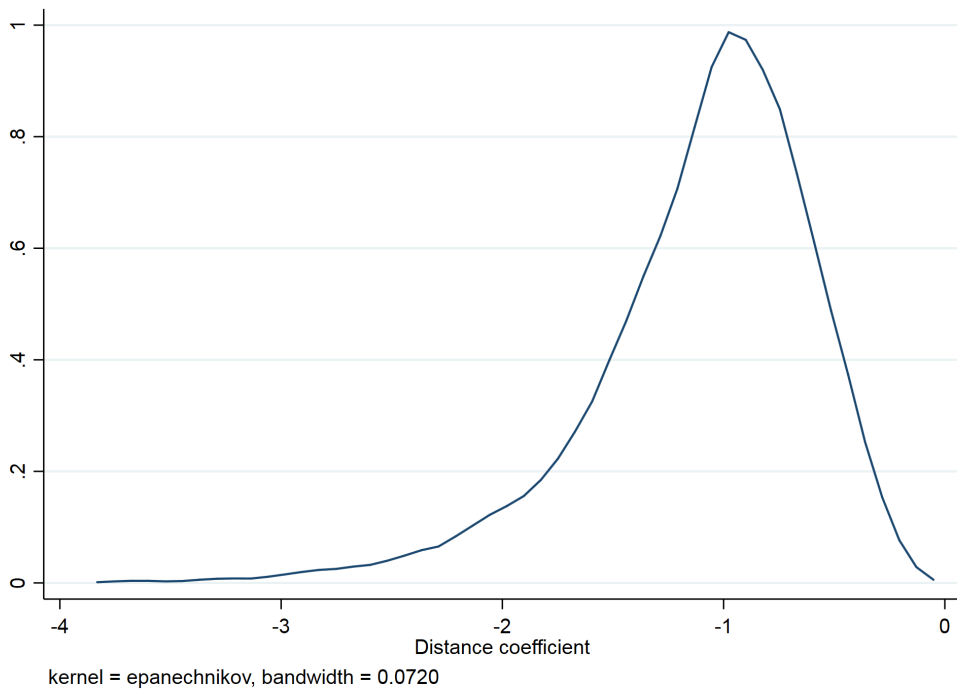
Source: Authors' calculations. Note: empirical distribution calculated on HS-6 products with $\varepsilon < 0$. For a proper comparison of OLS and PPML estimations, and focusing on the bias implied by the different weighting scheme (i.e. abstracting from the problem of the inclusion of zeros), both estimators have been employed on datasets without zero-trade flows.

Figure A2 – Empirical distribution of trade elasticity. Comparison between baseline results and ε obtained by constraining other trade costs elasticities to be constant within HS 4-digit heading.



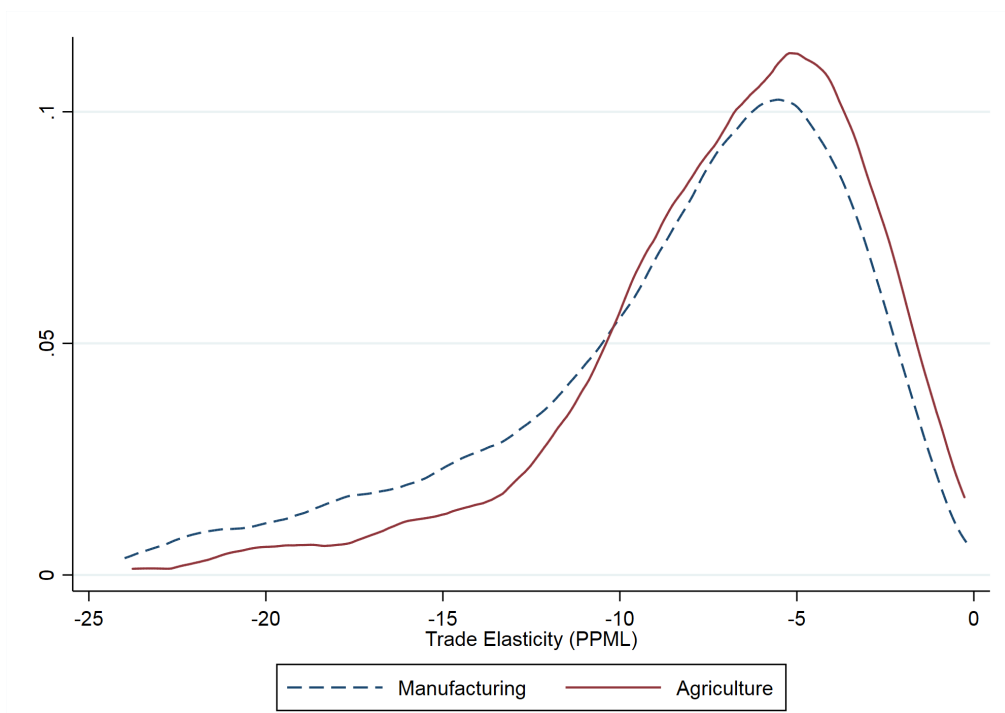
Source: Authors' calculations. Note: empirical distribution calculated on HS-6 products with negative distance elasticity.

Figure A3 – Empirical distribution of distance elasticity.



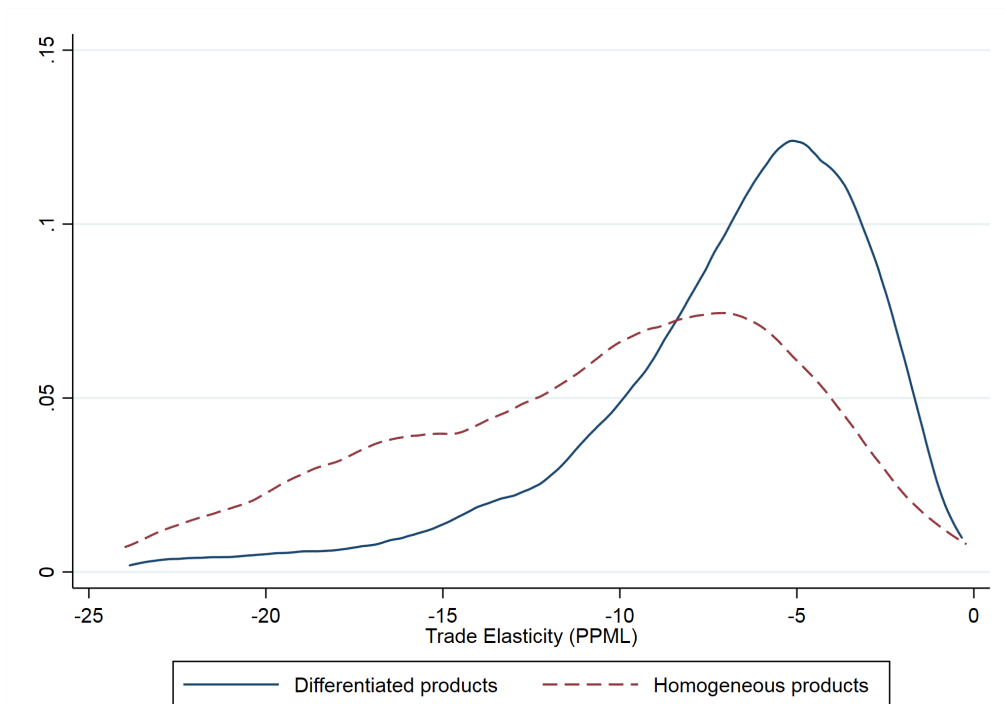
Source: Authors' calculations. Note: empirical distribution calculated on HS-6 products with negative distance elasticity.

Figure A4 – Empirical distribution of trade elasticity ϵ . Manufacturing vs. Agriculture sectors



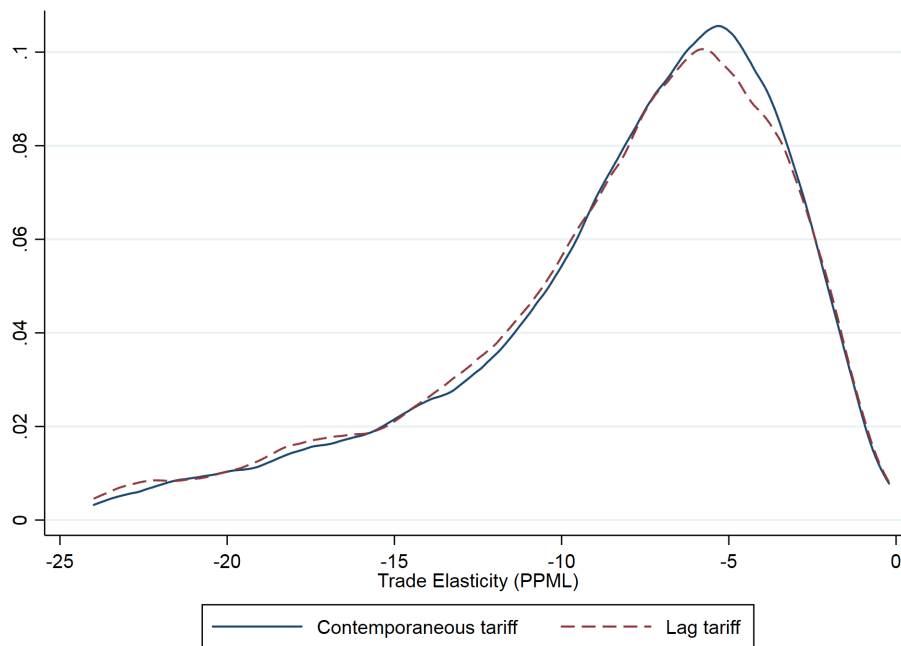
Source: Authors' calculations. Note: empirical distribution calculated on HS-6 products with $\epsilon < 0$.

Figure A5 – Empirical distribution of trade elasticity ϵ . Homogeneous vs Differentiated products (based on Rauch classification).



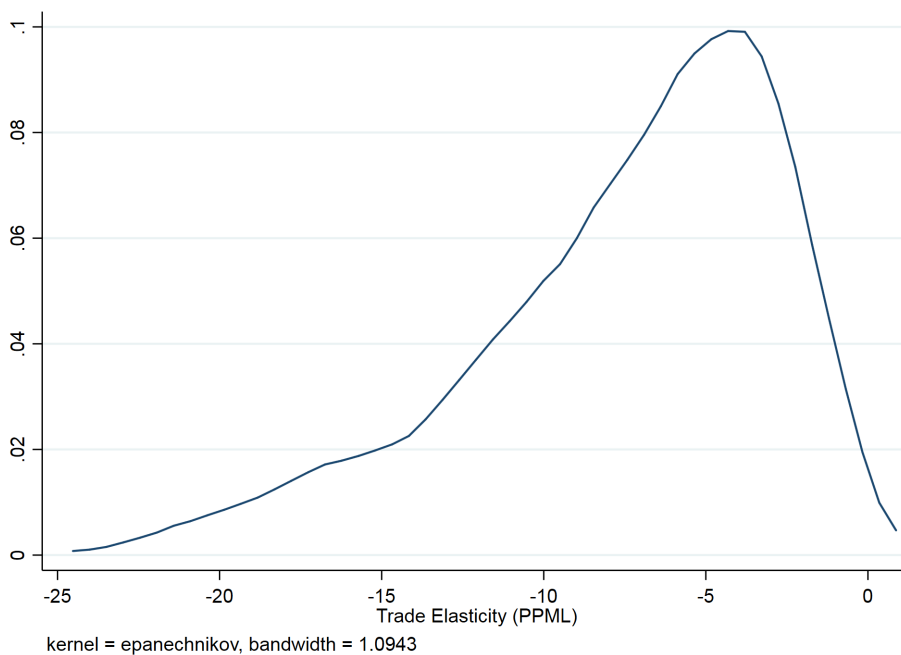
Source: Authors' calculations. Note: empirical distribution calculated on HS-6 products with $\epsilon < 0$.

Figure A6 – Empirical distribution of trade elasticity ε . Contemporaneous vs lag tariff estimations.



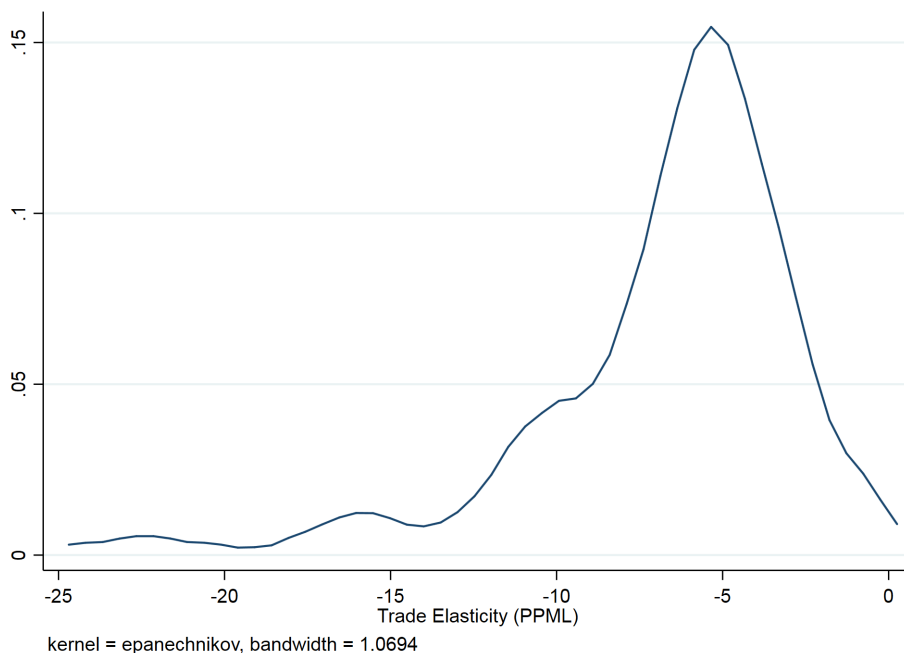
Source: Authors' calculations. Note: empirical distribution calculated on HS-6 products with $\varepsilon < 0$.

Figure A7 – Empirical distribution of trade elasticity ε across all HS 4-digit headings



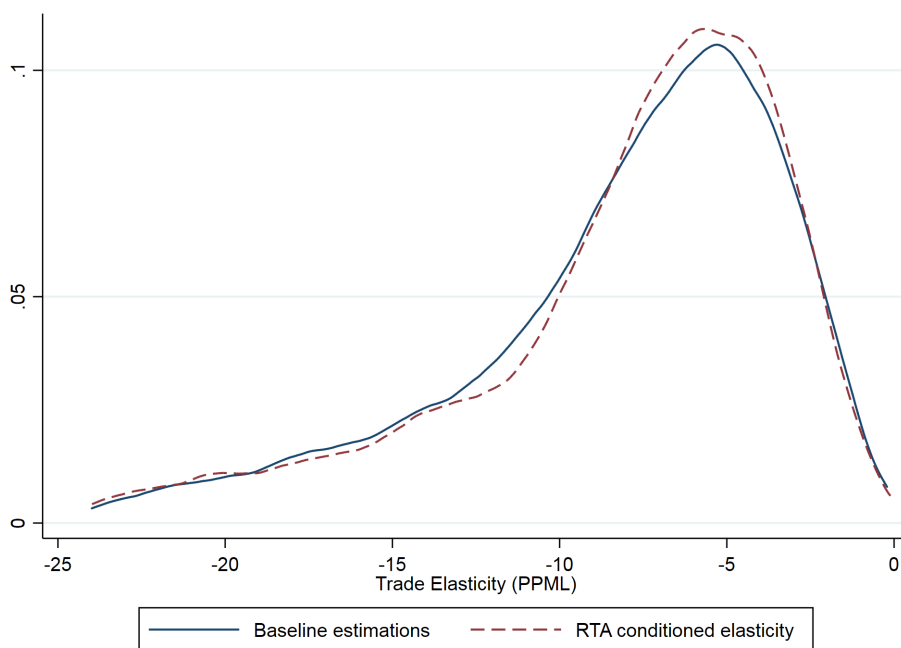
Source: Authors' calculations. Note: empirical distribution calculated on HS-6 products with $\varepsilon < 0$.

Figure A8 – Empirical distribution of trade elasticity ϵ across all HS 2-digit chapters



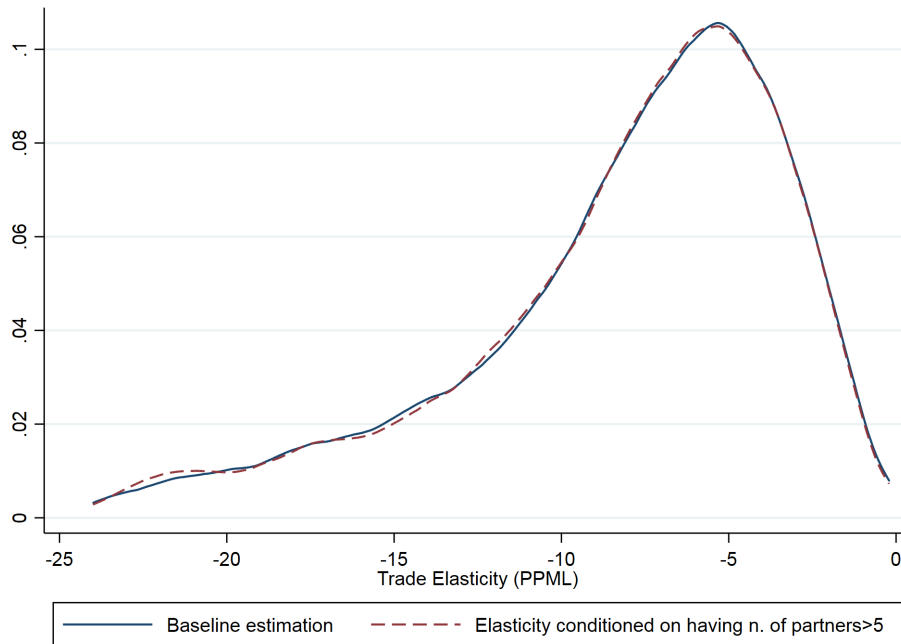
Source: Authors' calculations. Note: empirical distribution calculated on HS-6 products with $\epsilon < 0$.

Figure A9 – Empirical distribution of trade elasticity ϵ : (i) baseline, and (ii) conditioned on RTA dummy.



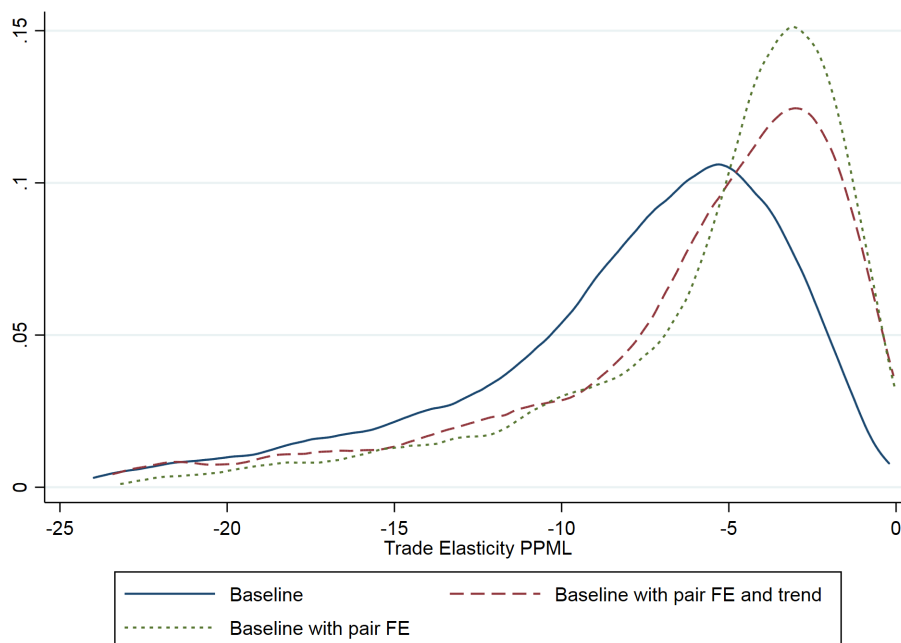
Source: Authors' calculations. Note: empirical distribution calculated on HS-6 products with $\epsilon < 0$.

Figure A10 – Empirical distribution of trade elasticity ε : (i) baseline, and (ii) conditioned on having more than five trade partners.



Source: Authors' calculations. Note: empirical distribution calculated on HS-6 products with $\varepsilon < 0$.

Figure A11 – Empirical distribution of trade elasticity ε : (i) baseline, (ii) conditioned on country-pair fixed effects, (iii) conditioned on country-pair specific trend.



Source: Authors' calculations. Note: empirical distribution calculated on HS-6 products with $\varepsilon < 0$.

B. Instrumental Variable approach

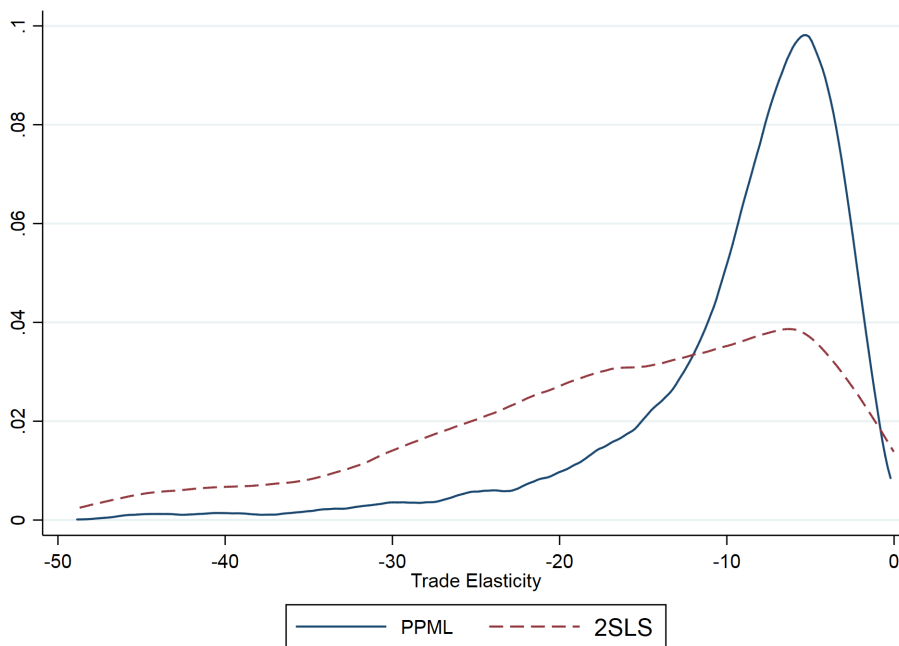
A 2SLS approach can be used to further reduce any endogeneity concern if one instruments bilateral tariff with the average tariff imposed by other importing countries $n \neq j$, within the same continent of importer j , on a given exporter-product. This is highly correlated with the bilateral tariff τ_{ijt} (relevant IV), and it does not affect directly the bilateral imports of country i from j (validity of the IV).

As instrument for bilateral tariff, for each product k , we use the average tariff imposed by other importing countries $n \neq j$ within the same continent of importer j on a given exporter i at time t : $\tau_{ijt}^{IV} = \frac{1}{N-1} \sum_{n \neq j}^{N-1} \tau_{int}$, where N is the total number of countries composing the continent of importer j . This instrumental variable has the same variability as bilateral tariff τ_{ijt} and allows us to keep the same specification as in equation 1. This IV can be considered valid: (i) if the amount of import of country j from i (on product k) does not affect the tariff scheme imposed by third countries n , and (ii) if the tariff imposed by third countries n affects the imports of j only through its effect on bilateral tariff τ_{ijt} . Notice that our IV is identical to the endogenous bilateral tariff if all the countries of a same continent belong to a custom union (in our definition of continent this is the case only for the EU). However this does not represent a problem in estimation as far as bilateral imports of country j do not affect the bilateral tariff imposed by the overall custom union. The exclusion restriction (ii) is plausibly satisfied because any exporter specific diversion effect (it specific) implied by a change in the third country n tariff is captured by it fixed effects. Similarly, any *average* reaction in tariff imposition by third countries n towards a given exporter i is (partially) captured by exporter-year fixed effects. This makes exclusion restriction (i) plausibly valid.

Trade elasticities ε based on 2SLS estimated tariff elasticities are reported in figure B1, dashed line. Using 2SLS approach, the average trade elasticity is qualitatively the same as that obtained by PPML estimations: *on average* reverse causality does not smooth the estimated elasticity to tariff β_0 . Indeed, would reverse causality play a role in our estimations, then after controlling for it with 2SLS, we should have obtained even stronger tariff elasticities

(more negative) and therefore stronger trade elasticities. In other words, we can reject the hypothesis that bilateral tariffs are set higher as a response of the competitive pressure of the exporter. However, it must be acknowledged that the 2SLS estimator does not produce statistically significant tariff elasticity for 3488 (out of 5023) products.⁶⁷ This may imply the highly dispersed distribution of 2SLS trade elasticities showed in this figure.

Figure B1 – Empirical distribution of trade elasticity ε . PPML vs 2SLS estimations. IV based on macro-region averages



Source: Authors' calculations. Note: empirical distribution calculated on HS-6 products with $\varepsilon < 0$.

⁶⁷This is due to the reduced power of the IV when the exporter-year fixed effect absorb most of the variation of our Instrumental Variable